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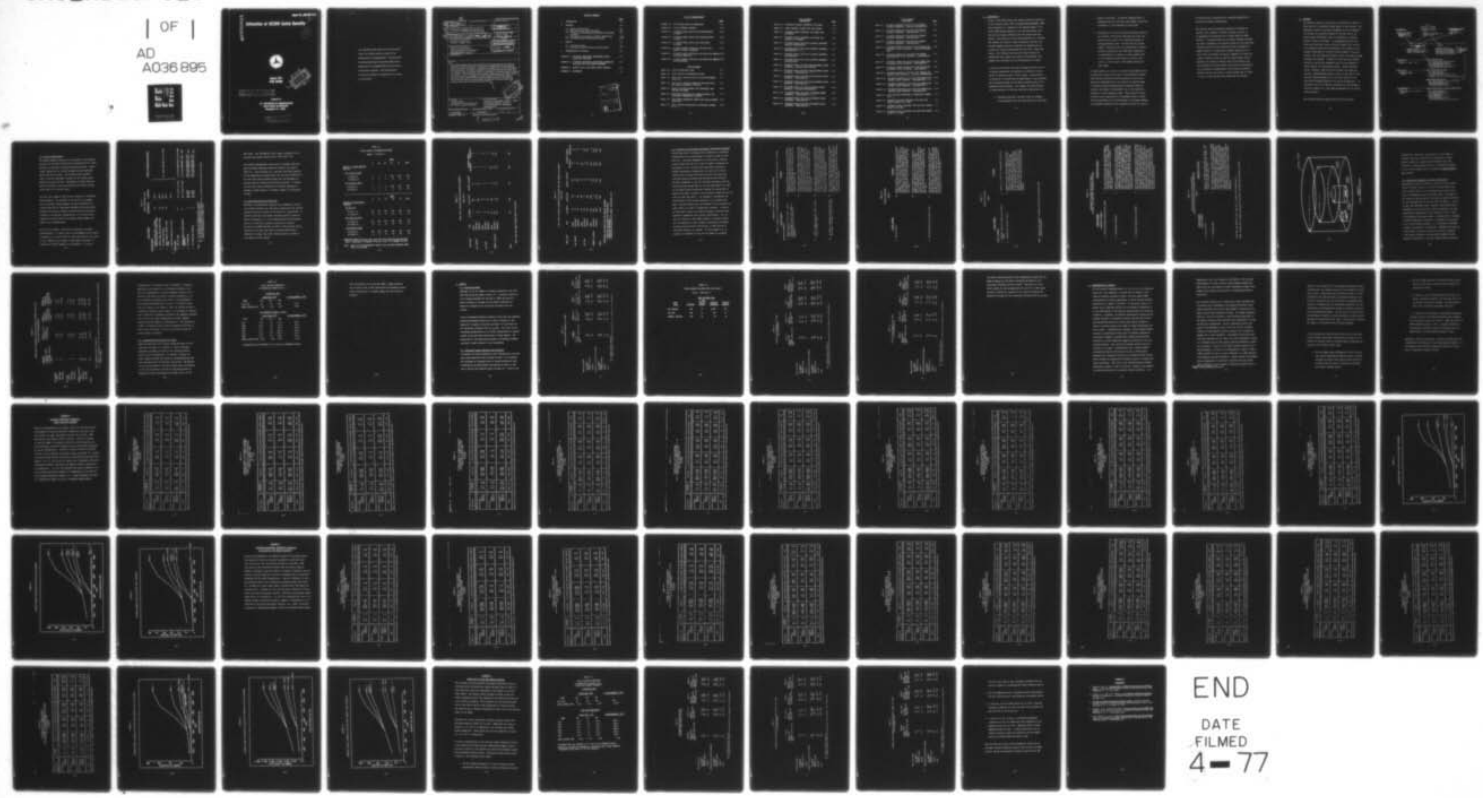

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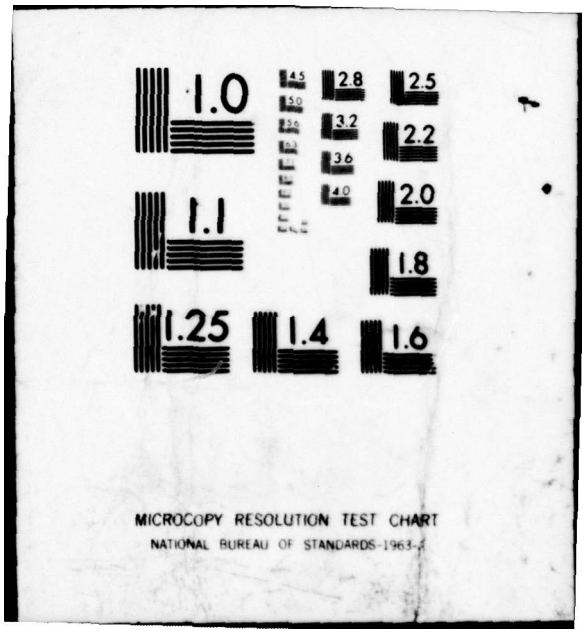
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Report No. FAA-AVP-77-8

Estimation of UG3RD Safety Benefits

January 1977
FINAL REPORT

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C. 20591

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16. Abstract

This study estimates the value of aviation safety improvements that could be obtained by implementing various alternative configurations of the Upgraded Third Generation ATC System. Estimates are based on the central assumption that the frequency of aviation accidents per operation observed in the past will be repeated unless identifiable steps are undertaken to eliminate specific classes of accidents. Recent accident data on midair collisions and controlled collisions with the terrain were examined to identify types of accidents that could be prevented by the UG3RD. "Preventable accident" rates were calculated and used to forecast future accidents under an extension of today's system and accidents that could be prevented by the UG3RD.

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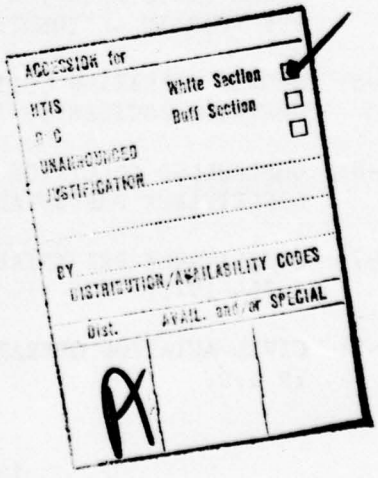

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1. INTRODUCTION

As part of the UG3RD System Cost Benefit Analysis conducted as a joint Aviation Policy (AVP) and Engineering Management (AEM) study (Reference 4), estimates of the expected impact of selected UG3RD system elements on civil aviation midair collisions and controlled collisions with the terrain have been derived. The objective of this safety analysis is to estimate and evaluate the relative losses (fatalities, injuries, and aircraft damage) that will conceivably be prevented by six alternative system configurations over the 1975 to 2000 time period. The following sections will briefly discuss the methodology used, present the results of the analysis, and suggest some limitations on the interpretation of results.

It should be noted that the results presented utilize one set of nominal assumptions and represent an estimate of the expected or average outcome of future events. Caution should be exercised in interpreting the significance of these expected value estimates because of the highly variable nature of the phenomenon being estimated. For example, two basic sources of large variation, of the many involved in this study, are:

1. Estimating historical accident rates for purposes of extrapolation into the future based on a very small

number of accidents. As specific examples given in subsequent sections will show, the inherent statistical variability of these estimates is quite high.

2. Estimating air carrier fatalities and serious injuries on the basis of historical fatalities per fatal accident and in the case of air carriers the growth in average passenger loads. On this basis the average number of fatalities per air carrier midair collision accident, assuming the year 2000 fleet composition, is approximately 65, however, a fatal accident with a fully loaded wide bodied type of aircraft could result in a 500 percent to 800 percent increase in this number.

For these reasons, it is best to interpret the estimates given in this study as what would result if the historical accident rates and loss rates were duplicated exactly in the future, except for adjustments due to the deletion of selected types of accidents based on implementing new accident prevention services, and except for adjustments due to the increase in average air carrier passenger loads. Other sources of variation such as the uncertainty of the monetary value of losses and the uncertainty of the effectiveness of the system elements in preventing accidents further emphasize the need for caution

in interpretation, particularly in ascribing significance to differences between configurations.

The approach used in developing estimates is described in Section 2 and a summary of results is given in Section 3. An assessment and interpretation of these results is given Section 4. Detailed results for the midair collision analysis are given in Appendix A and detailed results for the controlled collision with the terrain analysis is given in Appendix B. Summary results of a sensitivity analysis requested by the joint study team leaders are given in Appendix C in which the traffic forecast is based on half the annual growth rate exhibited by the nominal forecasts used in the primary study. This extremely low traffic growth projection was incorporated for the purpose of establishing a lower bound on estimated benefits and does not reflect a future outcome that is likely to occur if even the most dire predictions are realized.

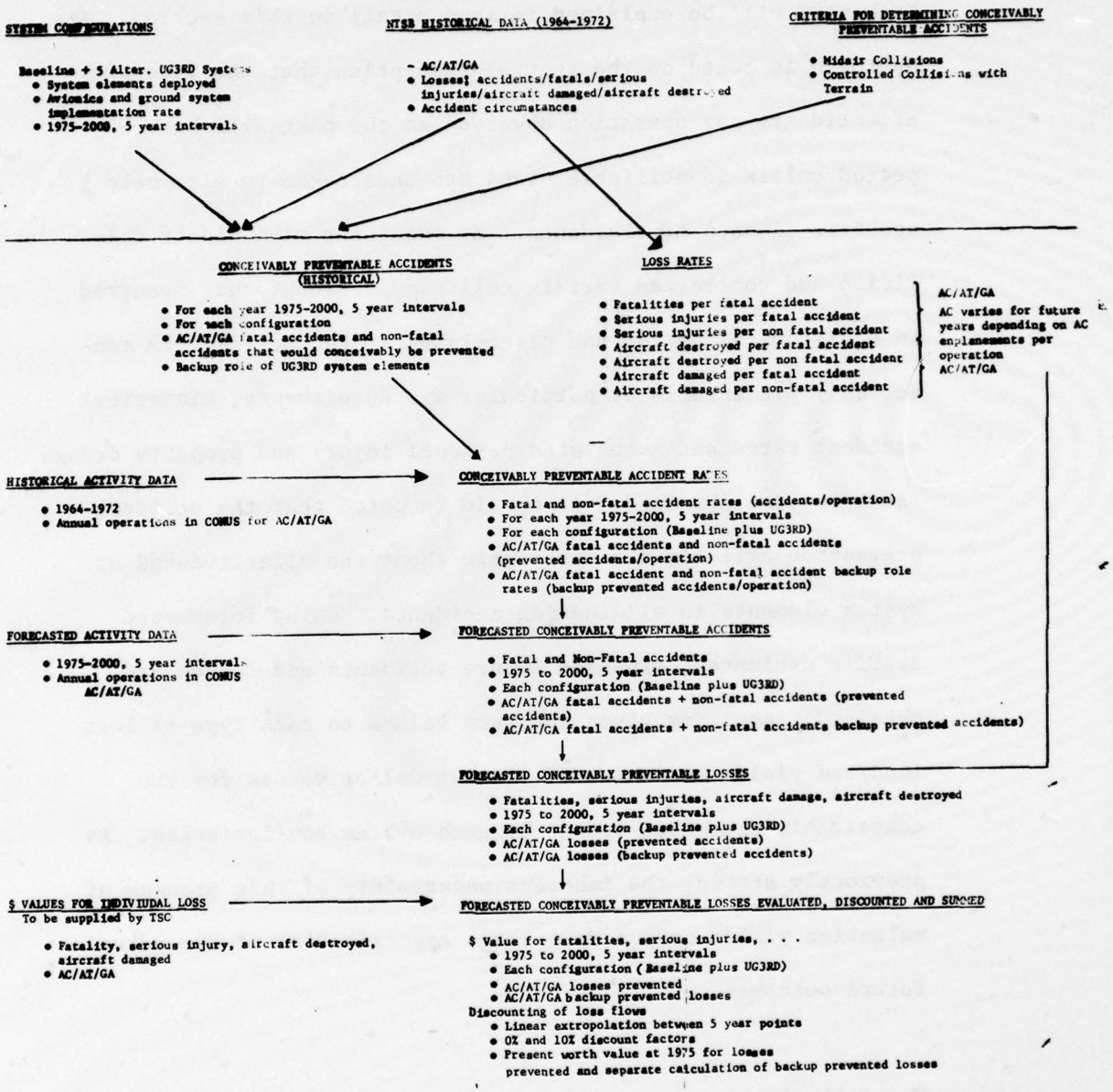
2. APPROACH

The approach utilized in this study is illustrated in Figure 2-1. Each step will be explained in some detail in this section. The approach is based on the central assumption that the frequency of accidents per operation observed in the past will be repeated unless identifiable steps are undertaken to eliminate specific classes of accidents. By examining each midair collision and controlled terrain collision accident that occurred in a historical period and determining if the accident is conceivably preventable by particular system elements, historical accident rates and associated personal injury and property damage estimates are obtained. It should be noted that the accident prevention criteria are optimistic about the effectiveness of system elements in eliminating accidents. Using forecasted traffic estimates, expected future accidents and losses are obtained. Applying given monetary values to each type of loss incurred yields estimates of the net dollar values for the conceivably prevented losses by each system configuration. As previously stated, the inherent uncertainty of this process of valuation yields only a very rough approximation of the actual future outcomes.

The following sections explain each step in more detail.

FIGURE 2-1

UG3RD SAFETY ANALYSIS METHODOLOGY



2.1 System Configurations

The system elements considered in the analysis of the baseline and the five alternative UG3RD system configurations are listed in Table 2-1 with their associated operational dates. "Operational" implies that all ground systems have been installed and are operating on-line. The indicated dates therefore imply a five-year deployment interval for all systems implemented in the post 1975 era. Assessment of system effectiveness will be made at five-year intervals with linear interpolation used for the interim years.

The first five elements listed will be referred to as Baseline System Elements. For purposes of this study it is assumed that all Baseline System Elements currently installed or in current plans will be operational throughout the study period. Although this tends to slightly overstate the near term effectiveness of the baseline configuration, it in no way affects comparative results because the baseline system elements are common to all configurations.

The last four elements listed will be referred to as UG3RD System Elements. In items 8 and 9 the 100 DABS/IPC sites roughly correspond to all current ARTS III sites plus some en route sites to give complete area coverage in high density corridors including the "Golden Triangle" in the Eastern U. S. and the

TABLE 2-1

SYSTEM OPERATIONAL DATES

SYSTEM ELEMENT	CONFIGURATION	# LOCATIONS	ASSUMED IMPLEMENTATION SCHEDULE
BASELINE SYSTEM			
1. TERMINAL CONTROL AREAS, EXTENDED RADAR SERVICE AREAS, CONTROL TOWERS	ALL	NOTE 1	ALL SITES OPERATIONAL 1975 TO 2000
2. CONFLICT ALERT AND EN ROUTE CONTROL	ALL	NOTE 1	
3. IFR TERRAIN ADVISORIES	ALL	NOTE 1	
4. GROUND PROXIMITY WARNING SYSTEM (GPWS)	ALL	NOTE 2	
5. PRECISION LANDING AIDS (ILS/MLS)		NOTE 3	
UG3RD SYSTEM			
6. ARTS III MSAW	1-5	TOP 30 ARTS III SITES	ALL SITES OPERATIONAL 1975 TO 2000
7. TERMINAL CONFLICT PREDICTION AND RESOLUTION	1-5	TOP 30 ARTS III SITES	ALL SITES OPERATIONAL 1980 - 2000
8. IPC BASED MSAW	4 5	100 SITES 300 SITES	FIRST SITE OPERATIONAL 1985, ALL SITES OPERATIONAL 1990 - 2000
9. IPC (COLLISION AVOIDANCE)	4 5	100 SITES 300 SITES	FIRST SITE OPERATIONAL 1985, ALL SITES OPERATIONAL 1990 - 2000

NOTES: (1) ALL EXISTING AND CURRENTLY PLANNED LOCATIONS
(2) ALL JET PUBLIC AIR TRANSPORTATION AIRCRAFT
(3) ALL EXISTING AND CURRENTLY PLANNED LOCATIONS PLUS ALL AIRPORTS WITH CERTIFICATED AIR CARRIER SERVICE (APPROXIMATELY 600 AIRPORTS TOTAL)

West Coast. The 300 DABS/IPC sites roughly correspond to the existing and planned terminal and en route radar sites.

The avionics implementation rates used to determine effectiveness of systems requiring cooperative avionics are given in Table 2-2. These estimates are consistent with those supplied by the Transportation Systems Center for the study (Reference 5). As can be seen these estimates assume that the deployment of general aviation cooperative surveillance avionics. It should be noted that linear interpolation in avionics equipage is assumed, so DABS avionics, for example, begins to be installed in 1985.

2.2 NTSB Historical Data (1964-1972)

Profiles of the historical accidents to be examined in the midair collision analysis and controlled collision with the terrain analysis are given in Table 2-3 and Table 2-4, respectively. It should be noted that the midair collision profile is given in terms of accidents, i.e., one collision involves two accidents. The set of historical collisions includes all accidents on file in the NTSB data base for 1964 to 1972 inclusive and is identical to the data base used in previous MITRE studies (Reference 2) except that those collisions which occurred on the runway have been deleted.

TABLE 2-2

UG3RD AVIONICS IMPLEMENTATION RATES

SOURCE: Reference 5

	YEAR					
	75	80	85	90	95	2000
PERCENT OF FLEET DABS/IPC EQUIPPED						
100 DABS/IPC SITES						
AC/LARGE AT	0	0	0	100	100	100
GA*/SMALL AT	0	0	0	35	70	70
300 DABS/IPC SITES						
AC/LARGE AT	0	0	0	100	100	100
GA*/SMALL AT	0	0	0	45	90	90

	YEAR					
	75	80	85	90	95	2000
PERCENT OF FLEET MODE C EQUIPPED						
NO DABS/IPC						
AC/LARGE AT	100	100	100	100	100	100
GA*/SMALL AT	15	25	35	40	40	40
100 DABS/IPC SITES						
AC/LARGE AT	100	100	100	100	100	100
GA*/SMALL AT	15	25	35	50	70	70
300 DABS/IPC SITES						
AC/LARGE AT	100	100	100	100	100	100
GA*/SMALL AT	15	25	35	60	90	90

*EXCLUDES CLASS F AIRCRAFT THAT HAVE ONLY VOICE COMM AND VOR RECEIVER, CLASS F REPRESENTS 11 PERCENT OF POP OF GA IN 75, 12 PERCENT IN 2000.

NOTE: LARGE AIR TAXI DESIGNATION GIVEN TO ALL AIR TAXIS WEIGHING MORE THAN 12,500 POUNDS.

TABLE 2-3

TOTAL CIVIL AVIATION MIDAIR COLLISION ACCIDENTS*

1964-1972

USER CLASS	TYPE	ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DAMAGE	
					DESTROYED	SUBSTANTIAL
AIR CARRIER	FATAL	7	246	34	7	0
	NON-FATAL	9	0	1	0	7
	SUBTOTAL	16	246	35	7	7
AIR TAXI	FATAL	4	13	2	4	0
	NON-FATAL	8	0	3	0	6
	SUBTOTAL	12	13	5	4	6
GENERAL AVIATION	FATAL	171	329	5	171	0
	NON-FATAL	276	0	39	54	171
	SUBTOTAL	447	329	44	225	171
TOTAL		475	588	84	236	184

*THIS TOTAL DOES NOT INCLUDE RUNWAY COLLISIONS

TABLE 2-4

TOTAL CIVIL AVIATION CONTROLLED COLLISION WITH THE TERRAIN ACCIDENTS*

1964-1972

USER CLASS	TYPE	ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DAMAGE	
					DESTROYED	SUBSTANTIAL
AIR CARRIER	FATAL	25	710	151	25	0
	NON-FATAL	39	0	10	4	32
	SUBTOTAL	64	710	161	29	32
AIR TAXI	FATAL	107	409	33	107	0
	NON-FATAL	173	0	45	22	149
	SUBTOTAL	280	409	78	129	149
GENERAL AVIATION	FATAL	1487	2758	218	1487	0
	NON-FATAL	4661	0	794	662	3970
	SUBTOTAL	6148	2758	1012	2149	3970
TOTAL		6492	3877	1251	2307	4151

*CONTROLLED COLLISIONS WITH THE TERRAIN INCLUDES:

- CONTROLLED COLLISIONS WITH GROUND/WATER
- CONTROLLED UNDERSHOOTS
- CONTROLLED COLLISIONS WITH TREES, WIRES/POLES, ETC.

2.3 Criteria for Determining Conceivably Preventable Accidents

Ground rules used to determine which accidents are conceivably preventable by each system element are given in Table 2-5 and Table 2-6. The basic assumption to all the midair collision criteria other than IPC (6) is that all midair collisions are preventable if the collision took place within existing or planned surveillance coverage where at least one of the two aircraft was in contact with the ATC facility and where the controller knew the position and altitude of both aircraft. The basic assumption to all the controlled collisions with the terrain criteria except GPWS (1) and IPC based MSAW (4) is that all accidents within surveillance coverage are preventable if position and Mode C altitude of the aircraft is known and the aircraft is under IFR control. For purposes of determining the effectiveness of IFR terrain advisories, it is assumed that Mode C altitude reports must be displayed to the controller via either ARTS III or ARTS II alphanumeric displays. It should be noted that criteria for baseline elements incorporate very optimistic assumptions about system effectiveness. As a result, the ability of some UG3RD elements to uniquely account for the prevention of many accidents, particularly accidents involving large aircraft, IFR aircraft, or VFR aircraft in controlled airspace, is subdued. For this reason it is of interest to determine not only the net number of accidents

TABLE 2-5

MIDAIR COLLISIONS

CRITERIA FOR CONCEIVABLY PREVENTABLE ACCIDENTS

(Refer to Figure 2-2 for representative airspace dimensions and ASR surveillance coverage)

SYSTEM ELEMENT	CRITERIA
(BASELINE ELEMENTS)	
1. Terminal Control Area, Group 1 and 2, (TCA 1, TCA 2) Terminal Radar Service Area (TRSA) or Extended Radar Service Group III (ERS III)	1a. Midair collisions that occurred within TCA/TRSA airspace will be prevented, as position and altitude will be known for all aircraft in this airspace and all aircraft will be contactable by the control facility, and
	1b. IFR aircraft versus IFR aircraft and IFR aircraft versus VFR Mode C aircraft midair collisions that occurred within ASR surveillance coverage (range 30 nmi, elevation angle 0.25°) but outside TCA/TRSA airspace will be prevented, as position and altitude will be known on both aircraft and at least one aircraft will be contactable by the control facility.
2a. ARTS II Equipped Extended Radar Service State II (ERS I, ERS II)	2a. IFR aircraft versus IFR aircraft and IFR aircraft versus VFR Mode C aircraft midair collisions that occurred within ASR surveillance coverage (range 30 nmi, 0.25° elevation angle) will be prevented as position and altitude will be known on both aircraft and at least one aircraft will be contactable by the control facility.
2b. Non ARTS II Equipped Extended Radar Service Stage I and Stage II (ERS I, ERS-II)	2b. IFR aircraft versus IFR aircraft midair collisions that occurred within ASR surveillance coverage (range 30 nmi, 0.25° elevation angle) will be prevented as position and altitude will be known on both aircraft and both aircraft will be contactable by the control facility.

TABLE 2-5

MIDAIR COLLISIONS

(CONT)

SYSTEM ELEMENT	CRITERIA
3. Control Tower	3a. Midair collisions that occurred at an uncontrolled airport which since the accident has had or is planned to have a control tower installed will be prevented if the collision occurred within control zone airspace, because the position and intent of both aircraft will be known to the control tower and both aircraft will be contactable by the control tower.
	3b. Midair collisions that occurred at a controlled airport which has had or is planned to have a BRITE display installed in the control tower will be prevented if the collision occurred within control zone airspace because the position and intent of both aircraft will be known to the tower and both aircraft will be contactable by the control tower.
4. En Route Control and Conflict Alert	4. IFR aircraft versus IFR aircraft and IFR aircraft versus VFR Mode C aircraft midair collisions occurring within ARSR surveillance coverage (range 110 nmi, elevation angle 0.25^{o}) will be prevented because the position and altitude of both aircraft will be known and at least one aircraft will be contactable by the control facility.

TABLE 2-5

MIDAIR COLLISIONS

(CONC)

SYSTEM ELEMENT	CRITERIA
(UG3RD ELEMENTS)	
5. Terminal Conflict Prediction and Resolution	5. Same as 1a, and 1b at designated facilities.
6. Intermittent Positive Control	6. DABS/IPC aircraft versus DABS/IPC aircraft midair collisions will be prevented if the collision occurred within DABS en route coverage (range 110 nmi, elevation angle 0.25°) and/or DABS terminal coverage (range 30 nmi, elevation angle 0.25°), because position and altitude of both aircraft will be known and at least one aircraft will be contactable by the automated collision avoidance function.

NOTE: IFR aircraft category includes VFR aircraft receiving radar advisory services.

TABLE 2-6

CONTROLLED COLLISIONS WITH THE TERRAIN
CRITERIA FOR CONCEIVABLY PREVENTABLE ACCIDENTS

SYSTEM ELEMENT	PREVENTION CRITERIA
(BASELINE ELEMENTS)	
1. Ground Proximity Warning System (GPWS)	1. All air carrier and air taxi aircraft weighing more than 12,500 pounds will have GPWS. Terrain collisions providing at least 12 seconds warning time will be prevented because of automatic pilot warning.
2. IFR Terrain Advisories	2. IFR Mode C equipped aircraft controlled collisions prevented within low altitude surveillance coverage of ARSR (range 30 nmi, elevation angle 0.25°) and ASR (range 5 to 30 nmi at ARTS II and ARTS III sites without BRITE displays in the tower, range 1 to 30 nmi at ARTS II and ARTS III sites with BRITE displays in the tower, elevation angle 0.25°) because position and altitude will be known and aircraft will be contactable by the control facility.
3. Precision Landing Aids (ILS/MLS)	3. Non-precision undershoot accidents in IFR weather that occurred at airports without full ILS at the time of the accident but that currently have or are planned to have a full ILS installed will be prevented if the aircraft have glide slope receivers, because of the vertical guidance information supplied to the pilot by a precision landing aid. All air carriers and air taxis are assumed to have glide slope receivers and 30 percent* of general aviation is expected to have glide slope receivers.

TABLE 2-6

CONTROLLED COLLISIONS WITH THE TERRAIN
CRITERIA FOR CONCEIVABLY PREVENTABLE ACCIDENTS

(CONC)

SYSTEM ELEMENT (UG3RD ELEMENTS)	PREVENTION CRITERIA
4. ARTS III MSAW	4. Same as 2 for MSAW equipped ARTS III sites. Surveillance coverage restricted to ASR (range 1 to 30 nmi, elevation angle 0.25°).
5. IPC Based MSAW	5. IFR or VFR terrain or obstacle collisions of DABS/IPC equipped aircraft will be prevented within low altitude DABS surveillance coverage of terminal sites (range 1 to 30 nmi, elevation angle 0.25°) and en route sites (range 30 nmi, elevation angle 0.25°), because the automated system can effectively alert pilot to necessary evasive action. Intentional high risk low altitude flights and VFR flights into IFR weather will not be prevented because of ineffectiveness of automated terrain advisories.

*From MLS Cost Benefit Study, ARD-730, 15 October 1975 (Reference 3).

NOTE: IFR aircraft category includes VFR aircraft receiving radar advisory services.

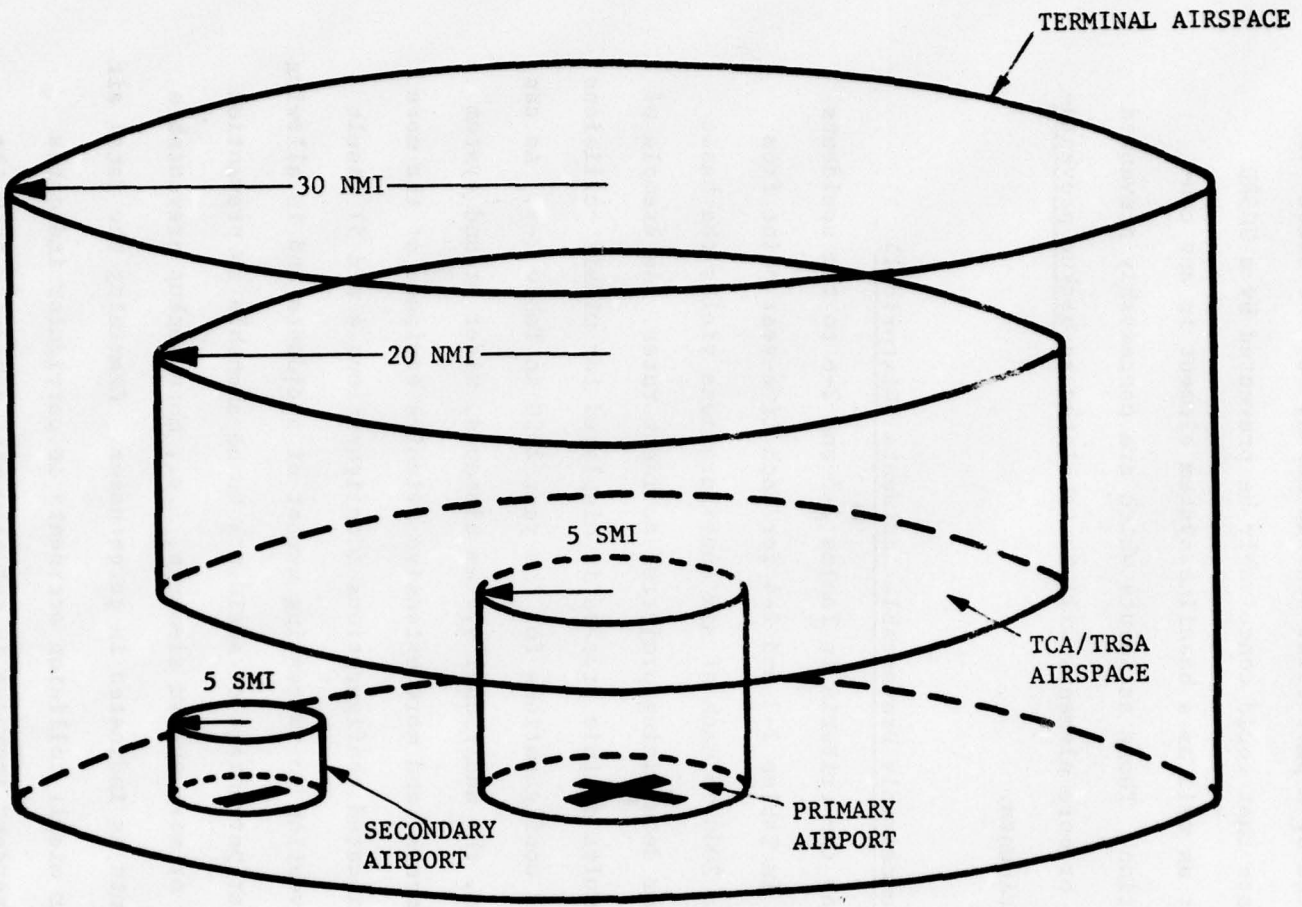


FIGURE 2-2
TYPICAL TERMINAL AIRSPACE

prevented by a particular configuration, but the number of accidents that could conceivably be prevented by a UG3RD element as well as a baseline system element in any configuration. Those accidents which are conceivably prevented by two or more elements will be tabulated as backup preventable accidents.

2.4 Conceivably Preventable Accidents (Historical)

Applying the criteria in Tables 2-5 and 2-6 to the accidents listed in Tables 2-3 and 2-4 for each five-year point from 1975 to 2000 in each of six configurations yields the basic data for determining projected accident rates. An example of the results of this process is displayed for midair collisions for all configurations for the year 2000 in Table 2-7. As can be seen, the additional system elements, wider ground system deployments, and more extensive avionics equipage of the more sophisticated configurations (Configurations 4 and 5) result in preventing an increasing number of accidents and in allowing a higher percentage of accidents to be amenable to prevention by two or more system elements, i.e., more backup preventable accidents as indicated in parentheses. Examining the fatal air carrier midair collision accidents in particular indicates a 100 percent increase in net prevented accidents from the baseline configuration to the most capable UG3RD alternative,

TABLE 2-7

CONCEIVABLY PREVENTABLE MIDAIR COLLISION ACCIDENTS (1964-1972)

(YEAR 2000 CONFIGURATIONS)

	BASELINE o TODAY'S SYSTEM o TCA/ERS o EN ROUTE CONFLICT ALERT	CONFIG. 1, 2, 3 o BASELINE o 30 TCP SITES	CONFIG. 4 o BASELINE o 30 TOP SITES o 100 DABS/IPC SITES	CONFIG. 5 o BASELINE o 30 TCP SITES o 300 DABS/IPC SITES
AIR CARRIER				
FATAL	3	3 (0)	4 (3)	6 (5)
NON-FATAL	6	6 (4)	6 (6)	7 (7)
SUB TOTAL	9	9 (4)	10 (9)	13 (12)
AIR TAXI				
FATAL	1	1 (0)	2 (1)	3 (1)
NON-FATAL	3	3 (2)	4 (2)	5 (2)
SUB TOTAL	4	4 (2)	6 (3)	8 (3)
GENERAL AVIATION				
FATAL	36	36 (5)	66 (23)	94 (29)
NON-FATAL	49	49 (5)	73 (11)	95 (15)
SUB TOTAL	85	85 (11)	139 (34)	189 (44)
TOTAL	98	98 (17)	155 (46)	210 (59)

TCP = Terminal Conflict Prediction

( ) = Number of accidents that are prevented by an UG3RD System element as well as a baseline system element.

configuration 5 (3 accidents versus 6 accidents). Perhaps as important as the increase in net prevented accidents is the fact that configuration 5 provides redundant solutions for 83 percent of the fatal air carrier accidents prevented, i.e. of the 6 accidents conceivably preventable, 5 are resolvable by both baseline and UG3RD system elements. It should be noted that the increase in the number of fatal air carrier accidents prevented by baseline system elements to 5 accidents in configuration 5 versus the 3 accidents prevented by the baseline configuration is due to the wider implementation of Mode C general aviation avionics assumed in configuration 5. The availability of Mode C in general aviation aircraft enhances the ability of radar control facilities to resolve IFR aircraft versus VFR aircraft midair collisions.

2.5 Forecasted Fatal Accidents and Losses

Using the historical civil aviation operations data and forecasts given in Table 2-8, estimates of future conceivably preventable accidents are made for the five-year interval points for each configuration. In addition, estimates of future losses prevented are derived by extrapolating the loss rates associated with the 1964-1972 time period. The historical air carrier fatality and serious injury rates are modified at five-year intervals to reflect the forecasted growth in average air carrier enplanements per flight from 27 for the

TABLE 2-8

CIVIL AVIATION OPERATIONS
AT CONTROLLED AIRPORTS IN U. S.

HISTORICAL DATA

	OPERATIONS (10^6)			AC ENPLANEMENTS (10^6)
YEAR	AC	AT	GA	
1964-1972	83	15*	299	1132
ANNUAL GROWTH RATE	3.0%	6.4%	6.7%	10.0%

FAA FORECASTS (APRIL 9, 1975)

	OPERATIONS (10^6)			AC ENPLANEMENTS (10^6)
YEAR	AC	AT	GA	
1975	9.8	2.5	46.2	200.7
1980	12.0	3.1	60.4	276.1
1985	13.5	4.7	94.7	346.0
1990	15.2	6.6	133.9	415.1
1995	17.0	8.0	163.2	502.1
2000	18.8	9.4	192.4	604.5
ANNUAL GROWTH RATE	2.64%	5.44%	5.87%	4.51%

* ESTIMATED FOR 1964 THROUGH 1971 AS 10% OF GA ITINERANT FLIGHTS

1964-1972 period to 64 in the year 2000. Losses prevented for the entire 1975 to 2000 time period are obtained by using linear interpolation to estimate losses for each five-year interval.

3. RESULTS

3.1 Forecasted Losses

Estimates of the net number of accidents prevented in the 1975-2000 time period are shown in Table 3-1. A detailed tabulation of the losses prevented for the 1975 to 2000 time period is given in Tables A-1 through A-5 for midair collisions and Tables B-1 through B-5 for controlled collisions with the terrain.

A plot of estimated accidents prevented versus year and estimated fatalities prevented versus year is given in Figure A-1 and Figure A-2 for midair collisions and Figure B-1 and Figure B-2 for controlled collisions with the terrain. The effect of the increasing sophistication of the UG3RD configurations is clearly evident in the post 1985 period shown in these figures. The backup role of the UG3RD system elements in providing redundant solutions to many accidents is also illustrated.

3.2 Forecasted Losses Evaluated and Discounted

To evaluate the losses prevented by each configuration, the unit loss values supplied by TSC as shown in Table 3-2 are applied. The resulting net estimated value of losses prevented by each configuration are shown without discounting in Table 3-3 and with a 10% per year discount factor in Table 3-4. Plots of the

TABLE 3-1

ESTIMATED ACCIDENTS PREVENTED (1975-2000)

	BASELINE	CONFIG 1,2,3		CONFIG 4		CONFIG 5	
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES		. BASELINE . 30 TCP and ARTS MSAW SITES . 100 DABS/IPC SITES		. BASELINE . 30 TCP and ARTS MSAW SITES . 300 DABS/IPC SITES	
MIDAIR COLLISIONS							
AIR CARRIER	41	41	(16)	43	(28)	48	(34)
AIR TAXI	39	39	(19)	47	(26)	59	(26)
GENERAL AVIATION	842	842	(94)	1128	(249)	1388	(311)
SUBTOTAL	922	922	(129)	1218	(303)	1495	(371)
CONTROLLED COLLISIONS WITH TERRAIN							
AIR CARRIER	132	132	(41)	132	(49)	134	(56)
AIR TAXI	99	99	(37)	149	(59)	225	(98)
GENERAL AVIATION	244	244	(28)	557	(150)	1061	(268)
SUBTOTAL	475	475	(106)	838	(258)	1420	(422)
TOTAL	1397	1397	(235)	2056	(561)	2915	(793)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Accidents also prevented by other elements in the configuration

TABLE 3-2

UG3RD AIRCRAFT ACCIDENT UNIT LOSS VALUES

Source: Reference 5

USER CLASS	COST PER UNIT LOSS $ (000) FATALITY	SERIOUS INJURY	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER	300	45	6,000	200
AIR TAXI	300	45	200	67
GENERAL AVIATION	300	38	50	16

TABLE 3-3

ESTIMATED LOSSES PREVENTED (1975-2000)
$M, NON-DISCOUNTED

	BASELINE	CONFIG 1, 2, 3	CONFIG 4	CONFIG 5
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES	. BASELINE . 30 TCP AND ARTS . 100 DABS/IPC SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 300 DABS/IPC SITES
MIDAIR COLLISIONS				
AIR CARRIER	375	375 (3)	452 (209)	580 (337)
AIR TAXI	13	13 (1)	19 (9)	27 (9)
GENERAL AVIATION	235	235 (31)	338 (104)	432 (128)
SUBTOTAL	623	623 (35)	809 (322)	1039 (474)
CONTROLLED COLLISIONS WITH TERRAIN				
AIR CARRIER	2245	2245 (746)	2245 (942)	2247 (1012)
AIR TAXI	92	92 (27)	138 (44)	206 (75)
GENERAL AVIATION	100	100 (12)	236 (57)	442 (105)
SUBTOTAL	2437	2437 (785)	2619 (1043)	2895 (1192)
TOTAL	3060	3060 (820)	3428 (1365)	3934 (1666)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Losses also prevented by other elements in the configuration

TABLE 3-4

ESTIMATED LOSSES PREVENTED (1975-2000)
$M, DISCOUNTED AT 10%

	BASELINE	CONFIG 1,2,3	CONFIG 4	CONFIG 5
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 100 DABS/IPC SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 300 DABS/IPC SITES
MIDAIR COLLISIONS				
AIR CARRIER	120	120 (1)	133 (34)	153 (54)
AIR TAXI	4	4 (0)	5 (2)	6 (2)
GENERAL AVIATION	66	66 (8)	81 (20)	95 (24)
SUBTOTAL	190	190 (9)	219 (56)	254 (79)
CONTROLLED COLLISIONS WITH TERRAIN				
AIR CARRIER	720	720 (239)	720 (272)	720 (284)
AIR TAXI	26	26 (8)	33 (10)	43 (15)
GENERAL AVIATION	26	26 (3)	47 (10)	79 (17)
SUBTOTAL	772	772 (250)	800 (292)	842 (316)
TOTAL	962	962 (259)	1019 (348)	1096 (395)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Losses also prevented by other elements in the configuration

net annual losses prevented by each configuration versus year are given in Figure A-3 for midair collisions and Figure B-3 for controlled collisions with the terrain. Tabulation of the net dollar losses for each configuration for the 1975 to 2000 period is given in Tables A-5 through A-12 for midair collisions and Tables B-5 through B-12 for controlled collisions with the terrain.

4. INTERPRETATION OF RESULTS

As can be seen by examining Table 3-1, 3-3, or 3-4, only configurations 4 and 5 are estimated to increase the net number of civil aviation accidents prevented, however, the less capable UG3RD configurations do provide enhancements to safety through redundant prevention for a number of accidents. As previously stated, the backup role is important because of the optimistic assumptions as to the effectiveness of the baseline system elements in preventing accidents. In general, the baseline configuration contains system elements directed to preventing accidents involving IFR aircraft and selected VFR aircraft in certain high density airspace by having a controller monitor the flight via radar surveillance and voice contact. Configurations 1 through 3 contain system elements directed to preventing the same types of accidents addressed by the baseline elements by automatically calling the controllers attention to certain imminently dangerous situations via the surveillance display. This controller alerting function serves exclusively as a backup. Configurations 4 and 5 extend accident prevention services to VFR aircraft as well as IFR aircraft equipped with cooperative avionics in all airspace within surveillance coverage by automatically alerting the pilot to certain dangerous situations. This direct pilot alerting function prevents additional accidents as well as serves as a backup to the controller monitoring process for previously covered situations. Con-

figurations 4 and 5 also indirectly contribute to the increased effectiveness of certain baseline system elements because more VFR aircraft are encouraged to install cooperative avionics which permits their position and altitude to be readily monitored by controllers.

The estimated differences in configuration losses prevented must be tempered with a knowledge of the inherent statistical uncertainty associated with the very small number of historical accidents on which these estimates are based. For example, comparing Table A-9 with A-12 indicates a $64M discounted improvement in the midair collision losses prevented with configuration 5 versus the baseline configuration. Further examination reveals that $33M of this difference is due to fatal air carrier accidents, $29M due to fatal general aviation accidents, and the small remainder due to other categories. Reviewing the historical 1964-1972 data indicates that the fatal air carrier difference is based on 3 accidents and the fatal general aviation difference is based on 60 accidents. Because of the highly variable nature of accident phenomenon, it would not be unreasonable to expect a -80% to +180% variation in the air carrier difference or a $\pm$30% variation in the general aviation difference.* Similar results are obtained from an examination of controlled collisions with the terrain. Thus, although it is not possible to explicitly express the net

*Based on 95% confidence intervals.

impact of this variability on the estimated differences between configurations, the inherent accuracy of the estimates is generally not good. Compounding the uncertainty attached to future outcomes are the large variation in potential fatalities with the use of wide body jets, the difficulty in determining those classes of accidents that are conceivably preventable, and the complications of estimating the timing of accidents introduced by the discounting procedure. The key point to be made is that the estimates are based on an exact duplication of past history and must be interpreted in that light. Actual future occurences are likely to vary greatly from the given estimates.

If the estimates are viewed as what would occur in the future if the accident history were repeated exactly except for the deletion of selected types of accidents based on deploying ATC services, the following results apply:

1. The full UG3RD system (Configuration 5) will conceivably prevent approximately 60% more midair collision accidents and nearly three times as many controlled collision with the terrain accidents as continuing with today's baseline system.

2. The full UG3RD system will conceivably prevent approximately a third more fatalities than continuing with the baseline system.

3. In addition, the full UG3RD system will provide a redundant prevention capability for more than 25% of the conceivably preventable accidents. And approximately 40% of the conceivably preventable fatalities.

4. A valuation of the increase in conceivably preventable accidents with the full UG3RD system above that estimated for the Baseline System over the 1975 - 2000 time period is $870M ($135M discounted at 10%). A nominal valuation of the redundant prevention capability provided by the full UG3RD system is $1,665M ($395M discounted at 10%).

Appropriate caveats as discussed in previous sections should be included with any discussion of the safety analysis results. To do otherwise could seriously mislead the reader as to the impact of alternative courses of action.

APPENDIX A

ESTIMATED CONCEIVABLY PREVENTABLE MIDAIR COLLISION ACCIDENTS

Listed in this appendix is the computer output for the safety estimation program for fatal and non-fatal accidents for each user class (air carrier, air taxi, and general aviation) for the 1975 - 2000 time period in the midair collision category. Tables A-1 through A-4 give the number of accidents, fatalities, serious injuries, aircraft destroyed, and aircraft damaged that are conceivably preventable by the six configurations. Tables A-5 through A-8 give the estimated value of the conceivably preventable losses, and Tables A-9 through A-12 restate these results incorporating a 10% annual discounting factor. Figures A-1, A-2, and A-3 give an annual plot of estimated conceivably preventable accidents, fatalities, and monetary losses, respectively, by configuration. In all of the estimates the value of redundant accident solutions provided by elements of Configuration 1-6 is indicated by the backup preventable category, i.e., losses conceivably prevented by a UG3RD System element as well as a Baseline System element.

TABLE A-1

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	14 (0)	939 (0)	131 (0)	14 (0)	0 (0)
NON-FATAL	27 (0)	**** (****)	38 (0)	0 (0)	21 (0)
SUBTOTAL	41 (0)	939 (0)	169 (0)	14 (0)	21 (0)
AIR TAXI					
FATAL	10 (0)	31 (0)	4 (0)	10 (0)	0 (0)
NON-FATAL	29 (0)	**** (****)	11 (0)	0 (0)	21 (0)
SUBTOTAL	39 (0)	31 (0)	15 (0)	10 (0)	21 (0)
GENERAL AVIATION					
FATAL	355 (0)	684 (0)	11 (0)	355 (0)	0 (0)
NON-FATAL	487 (0)	**** (****)	69 (0)	95 (0)	303 (0)
SUBTOTAL	842 (0)	684 (0)	80 (0)	450 (0)	303 (0)
TOTAL	922 (0)	1654 (0)	264 (0)	474 (0)	345 (0)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-2

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION 1, 2, 3 YEARS 1975-2000
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	14 (0)	939 (0)	131 (0)	14 (0)	0 (0)
NON-FATAL	27 (16)	**** (****)	38 (19)	0 (0)	21 (13)
SUBTOTAL	41 (16)	939 (0)	169 (19)	14 (0)	21 (13)
AIR TAXI					
FATAL	10 (0)	31 (0)	4 (0)	10 (0)	0 (0)
NON-FATAL	29 (19)	**** (****)	11 (6)	0 (0)	21 (14)
SUBTOTAL	39 (19)	31 (0)	15 (6)	10 (0)	21 (14)
GENERAL AVIATION					
FATAL	355 (47)	684 (91)	11 (0)	355 (47)	0 (0)
NON-FATAL	487 (47)	**** (****)	69 (6)	95 (9)	303 (30)
SUBTOTAL	842 (94)	684 (91)	80 (6)	450 (56)	303 (30)
TOTAL	922 (129)	1654 (91)	264 (31)	474 (56)	345 (57)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION 4 YEARS 1975-2000
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	16 (7)	1139 (531)	159 (74)	16 (7)	0 (0)
NON-FATAL	27 (21)	**** (****)	38 (19)	0 (0)	21 (16)
SUBTOTAL	43 (28)	1139 (531)	197 (93)	16 (7)	21 (16)
AIR TAXI					
FATAL	14 (7)	46 (21)	8 (2)	14 (7)	0 (0)
NON-FATAL	33 (19)	**** (****)	12 (6)	0 (0)	25 (14)
SUBTOTAL	47 (26)	46 (21)	20 (8)	14 (7)	25 (14)
GENERAL AVIATION					
FATAL	512 (163)	987 (312)	15 (4)	512 (163)	0 (0)
NON-FATAL	616 (86)	**** (****)	88 (13)	120 (16)	381 (53)
SUBTOTAL	1128 (249)	987 (312)	103 (17)	632 (179)	381 (53)
TOTAL	1218 (303)	2172 (864)	320 (118)	662 (193)	427 (83)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-4

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:3?

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	19 (11)	1471 (864)	205 (120)	19 (11)	0 (0)
NON-FATAL	29 (23)	**** (****)	38 (19)	0 (0)	23 (18)
SUBTOTAL	48 (34)	1471 (864)	243 (139)	19 (11)	23 (18)
AIR TAXI					
FATAL	21 (7)	66 (21)	10 (2)	21 (7)	0 (0)
NON-FATAL	38 (19)	**** (****)	13 (6)	0 (0)	28 (14)
SUBTOTAL	59 (26)	66 (21)	23 (8)	21 (7)	28 (14)
GENERAL AVIATION					
FATAL	659 (200)	1267 (384)	19 (6)	659 (200)	0 (0)
NON-FATAL	729 (111)	**** (****)	103 (15)	142 (21)	452 (68)
SUBTOTAL	1388 (311)	1267 (384)	122 (21)	801 (221)	452 (68)
TOTAL	1495 (371)	2804 (1269)	388 (168)	841 (239)	503 (100)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-5

ESTIMATED VALUE OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	14 (0)	282.3 (0.0)	5.9 (0.0)	81.3 (0.0)	0.0 (0.0)	369 (0)
NON-FATAL	27 (0)	****** (******)	1.7 (0.0)	0.0 (0.0)	4.2 (0.0)	6 (0)
SUBTOTAL	41 (0)	282.3 (0.0)	7.5 (0.0)	81.3 (0.0)	4.2 (0.0)	375 (0)
AIR TAXI						
FATAL	10 (0)	9.3 (0.0)	0.2 (0.0)	1.9 (0.0)	0.0 (0.0)	11 (0)
NON-FATAL	29 (0)	****** (******)	0.5 (0.0)	0.0 (0.0)	1.4 (0.0)	2 (0)
SUBTOTAL	39 (0)	9.3 (0.0)	0.7 (0.0)	1.9 (0.0)	1.4 (0.0)	13 (0)
GENERAL AVIATION						
FATAL	355 (0)	204.9 (0.0)	3.4 (0.0)	17.8 (0.0)	0.0 (0.0)	223 (0)
NON-FATAL	487 (0)	****** (******)	2.6 (0.0)	4.8 (0.0)	4.8 (0.0)	12 (0)
SUBTOTAL	842 (0)	204.9 (0.0)	3.0 (0.0)	22.5 (0.0)	4.8 (0.0)	235 (0)
TOTAL	922 (0)	497 (0)	11 (0)	106 (0)	10 (0)	624 (0)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-6

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 1,2,3 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 75
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	14 (0)	282.3 (0.0)	5.9 (0.0)	81.3 (0.0)	0.0 (0.0)	369 (0)
NON-FATAL	27 (16)	****** (******)	1.7 (0.9)	0.0 (0.0)	4.2 (2.6)	6 (3)
SUBTOTAL	41 (16)	282.3 (0.0)	7.5 (0.9)	81.3 (0.0)	4.2 (2.6)	375 (3)
AIR TAXI						
FATAL	10 (0)	9.3 (0.0)	0.2 (0.0)	1.9 (0.0)	0.0 (0.0)	11 (0)
NON-FATAL	29 (19)	****** (******)	0.5 (0.3)	0.0 (0.0)	1.4 (0.9)	2 (1)
SUBTOTAL	39 (19)	9.3 (0.0)	0.7 (0.3)	1.9 (0.0)	1.4 (0.9)	13 (1)
GENERAL AVIATION						
FATAL	355 (47)	204.9 (27.4)	0.4 (0.1)	17.8 (2.4)	0.0 (0.0)	223 (30)
NON-FATAL	487 (47)	****** (******)	2.6 (0.3)	4.8 (0.5)	4.8 (0.5)	12 (1)
SUBTOTAL	842 (94)	204.9 (27.4)	3.0 (0.3)	22.5 (2.8)	4.8 (0.5)	235 (31)
TOTAL	922 (129)	497 (27)	11 (1)	106 (3)	10 (4)	624 (36)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-7

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 4 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	16 (7)	341.9 (159.3)	7.1 (3.3)	97.0 (41.7)	0.0 (0.0)	446 (204)
NON-FATAL	27 (21)	****** (******)	1.7 (0.9)	0.0 (0.0)	4.2 (3.4)	6 (4)
SUBTOTAL	43 (28)	341.9 (159.3)	8.8 (4.2)	97.0 (41.7)	4.2 (3.4)	452 (209)
AIR TAXI						
FATAL	14 (7)	13.6 (6.4)	0.3 (0.1)	2.8 (1.3)	0.0 (0.0)	17 (8)
NON-FATAL	33 (19)	****** (******)	0.6 (0.3)	0.0 (0.0)	1.7 (0.9)	2 (1)
SUBTOTAL	47 (26)	13.6 (6.4)	0.9 (0.5)	2.8 (1.3)	1.7 (0.9)	19 (9)
GENERAL AVIATION						
FATAL	512 (163)	296.0 (93.9)	0.6 (0.2)	25.6 (8.1)	0.0 (0.0)	322 (102)
NON-FATAL	616 (86)	****** (******)	3.3 (0.5)	6.0 (0.8)	6.1 (0.9)	15 (2)
SUBTOTAL	1128 (249)	296.0 (93.9)	3.9 (0.6)	31.7 (9.0)	6.1 (0.9)	338 (104)
TOTAL	1218 (303)	651 (260)	14 (5)	131 (52)	12 (5)	808 (322)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-8

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	19 (11)	441.6 (259.0)	9.2 (5.4)	123.0 (67.7)	0.0 (0.0)	574 (332)
NON-FATAL	29 (23)	****** (******)	1.7 (0.9)	0.0 (0.0)	4.4 (3.7)	6 (5)
SUBTOTAL	48 (34)	441.6 (259.0)	10.8 (6.2)	123.0 (67.7)	4.4 (3.7)	580 (337)
AIR TAXI						
FATAL	21 (7)	19.9 (6.4)	0.5 (0.1)	4.1 (1.3)	0.0 (0.0)	24 (8)
NON-FATAL	38 (19)	****** (******)	0.6 (0.3)	0.0 (0.0)	1.9 (0.9)	3 (1)
SUBTOTAL	59 (26)	19.9 (6.4)	1.1 (0.5)	4.1 (1.3)	1.9 (0.9)	27 (9)
GENERAL AVIATION						
FATAL	659 (200)	380.4 (115.3)	0.7 (0.2)	33.0 (10.0)	0.0 (0.0)	414 (125)
NON-FATAL	729 (111)	****** (******)	3.9 (0.6)	7.1 (1.1)	7.2 (1.1)	18 (3)
SUBTOTAL	1388 (311)	380.4 (115.3)	4.6 (0.8)	40.1 (11.1)	7.2 (1.1)	432 (128)
TOTAL	1495 (371)	842 (381)	17 (7)	167 (80)	14 (6)	1039 (474)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A- 9

ESTIMATED VALUE OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	14 (0)	88.3 (0.0)	1.8 (0.0)	27.8 (0.0)	0.0 (0.0)	118 (0)
NON-FATAL	27 (0)	****** (******)	0.9 (0.0)	0.0 (0.0)	1.4 (0.0)	2 (0)
SUBTOTAL	41 (0)	88.3 (0.0)	2.7 (0.0)	27.8 (0.0)	1.4 (0.0)	120 (0)
AIR TAXI						
FATAL	1) (0)	2.7 (0.0)	0.1 (0.0)	0.6 (0.0)	0.0 (0.0)	3 (0)
NON-FATAL	29 (0)	****** (******)	0.1 (0.0)	0.0 (0.0)	0.4 (0.0)	1 (0)
SUBTOTAL	39 (0)	2.7 (0.0)	0.2 (0.0)	0.6 (0.0)	0.4 (0.0)	4 (0)
GENERAL AVIATION						
FATAL	255 (0)	57.7 (0.0)	0.1 (0.0)	5.0 (0.0)	0.0 (0.0)	63 (0)
NON-FATAL	467 (0)	****** (******)	0.7 (0.0)	1.4 (0.0)	1.4 (0.0)	3 (0)
SUBTOTAL	842 (0)	57.7 (0.0)	0.9 (0.0)	6.4 (0.0)	1.4 (0.0)	66 (0)
TOTAL	922 (0)	149 (0)	4 (0)	35 (0)	3 (0)	190 (0)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-10

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 1,2, & YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	14 (0)	88.3 (0.0)	1.8 (0.0)	27.8 (0.0)	0.0 (0.0)	118 (0)
NON-FATAL	27 (16)	****** (******)	0.9 (0.3)	0.0 (0.0)	1.4 (0.8)	2 (1)
SUBTOTAL	41 (16)	88.3 (0.0)	2.7 (0.3)	27.8 (0.0)	1.4 (0.8)	120 (1)
AIR TAXI						
FATAL	10 (0)	2.7 (0.0)	0.1 (0.0)	0.6 (0.0)	0.0 (0.0)	3 (0)
NON-FATAL	25 (19)	****** (******)	0.1 (0.1)	0.0 (0.0)	0.4 (0.2)	1 (0)
SUBTOTAL	39 (19)	2.7 (0.0)	0.2 (0.1)	0.6 (0.0)	0.4 (0.2)	4 (0)
GENERAL AVIATION						
FATAL	355 (47)	57.7 (7.0)	0.1 (0.0)	5.0 (0.6)	0.0 (0.0)	63 (8)
NON-FATAL	487 (47)	****** (******)	0.7 (0.1)	1.4 (0.1)	1.4 (0.1)	3 (0)
SUBTOTAL	842 (94)	57.7 (7.0)	0.9 (0.1)	6.4 (0.7)	1.4 (0.1)	66 (8)
TOTAL	922 (129)	149 (7)	4 (1)	35 (1)	3 (1)	190 (9)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-11

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 4 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	16 (7)	98.4 (25.4)	2.0 (0.5)	30.5 (6.8)	0.0 (0.0)	131 (33)
NON-FATAL	27 (21)	****** (******)	0.9 (0.3)	0.0 (0.0)	1.4 (0.9)	2 (1)
SUBTOTAL	43 (28)	98.4 (25.4)	2.9 (0.9)	30.5 (6.8)	1.4 (0.9)	133 (34)
AIR TAXI						
FATAL	14 (7)	3.3 (1.1)	0.1 (0.0)	0.7 (0.2)	0.0 (0.0)	4 (1)
NON-FATAL	33 (19)	****** (******)	0.1 (0.1)	0.0 (0.0)	0.4 (0.2)	1 (0)
SUBTOTAL	47 (26)	3.3 (1.1)	0.2 (0.1)	0.7 (0.2)	0.4 (0.2)	5 (2)
GENERAL AVIATION						
FATAL	512 (163)	70.9 (17.8)	0.1 (0.0)	6.1 (1.5)	0.0 (0.0)	77 (19)
NON-FATAL	616 (86)	****** (******)	0.8 (0.1)	1.5 (0.2)	1.6 (0.2)	4 (0)
SUBTOTAL	1128 (249)	70.9 (17.8)	1.0 (0.1)	7.7 (1.7)	1.6 (0.2)	81 (20)
TOTAL	1218 (303)	173 (44)	4 (1)	39 (9)	3 (1)	219 (55)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE A-12

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF MIDAIR COLLISIONS
UG3RD COST BENEFIT STUDY
20 JAN 76
13: 6:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	19 (11)	113.7 (40.7)	2.4 (0.8)	34.5 (10.8)	0.0 (0.0)	151 (52)
NON-FATAL	29 (23)	****** (******)	0.9 (0.3)	0.0 (0.0)	1.4 (0.9)	2 (1)
SUBTOTAL	48 (34)	113.7 (40.7)	3.2 (1.2)	34.5 (10.8)	1.4 (0.9)	153 (54)
AIR TAXI						
FATAL	21 (7)	4.3 (1.1)	0.1 (0.0)	0.9 (0.2)	0.0 (0.0)	5 (1)
NON-FATAL	38 (19)	****** (******)	0.2 (0.1)	0.0 (0.0)	0.5 (0.2)	1 (0)
SUBTOTAL	59 (26)	4.3 (1.1)	0.3 (0.1)	0.9 (0.2)	0.5 (0.2)	6 (2)
GENERAL AVIATION						
FATAL	653 (200)	83.1 (21.2)	0.2 (0.0)	7.2 (1.8)	0.0 (0.0)	90 (23)
NON-FATAL	729 (111)	****** (******)	0.9 (0.1)	1.7 (0.2)	1.7 (0.2)	4 (1)
SUBTOTAL	1388 (311)	83.1 (21.2)	1.1 (0.2)	8.9 (2.1)	1.7 (0.2)	95 (24)
TOTAL	1495 (371)	201 (63)	5 (1)	44 (13)	4 (1)	254 (79)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES.

FIGURE A-1

ESTIMATED ANNUAL MIDAIR COLLISION ACCIDENTS PREVENTED

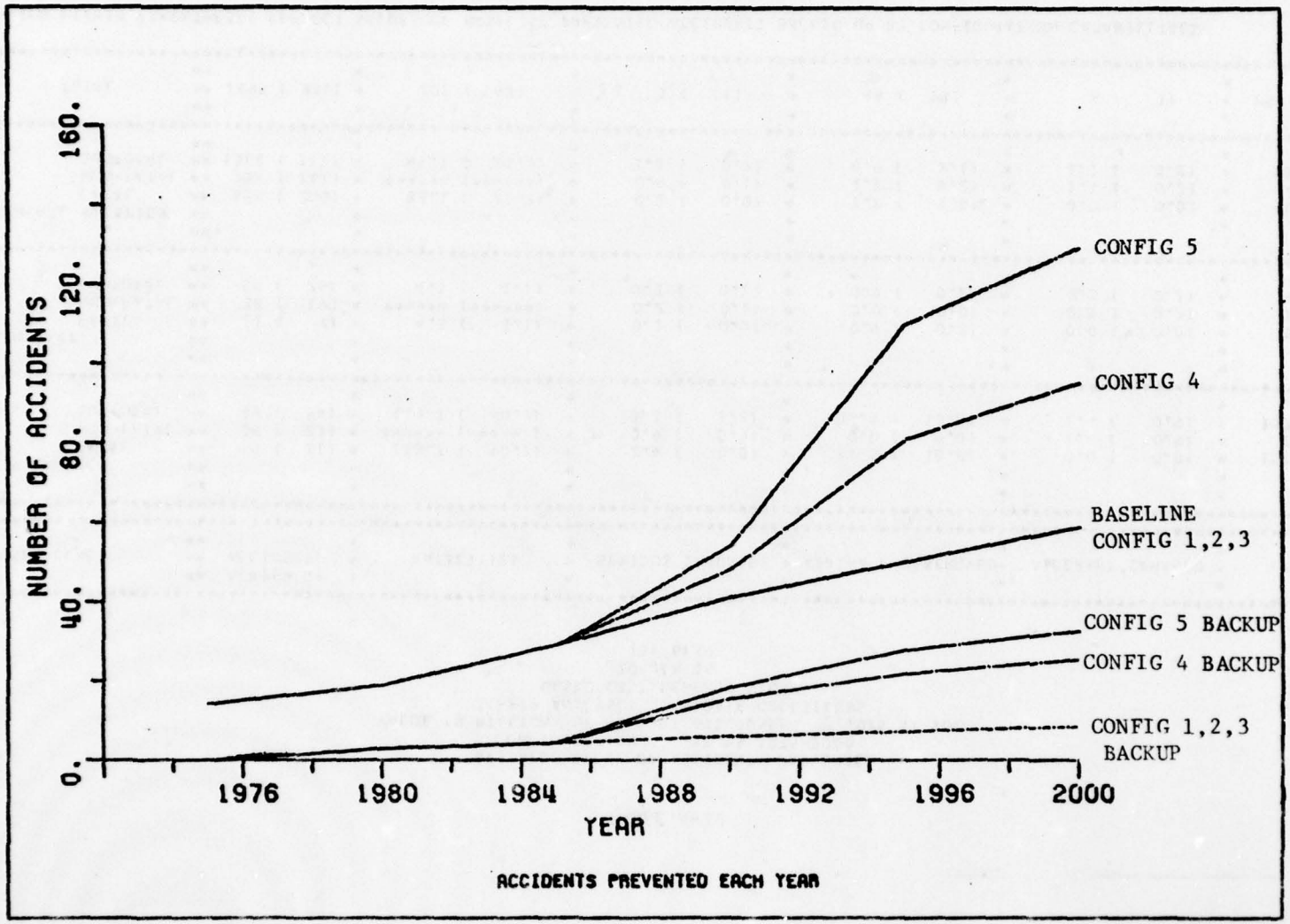


FIGURE A-2

ESTIMATED ANNUAL MIDAIR COLLISION FATALITIES PREVENTED

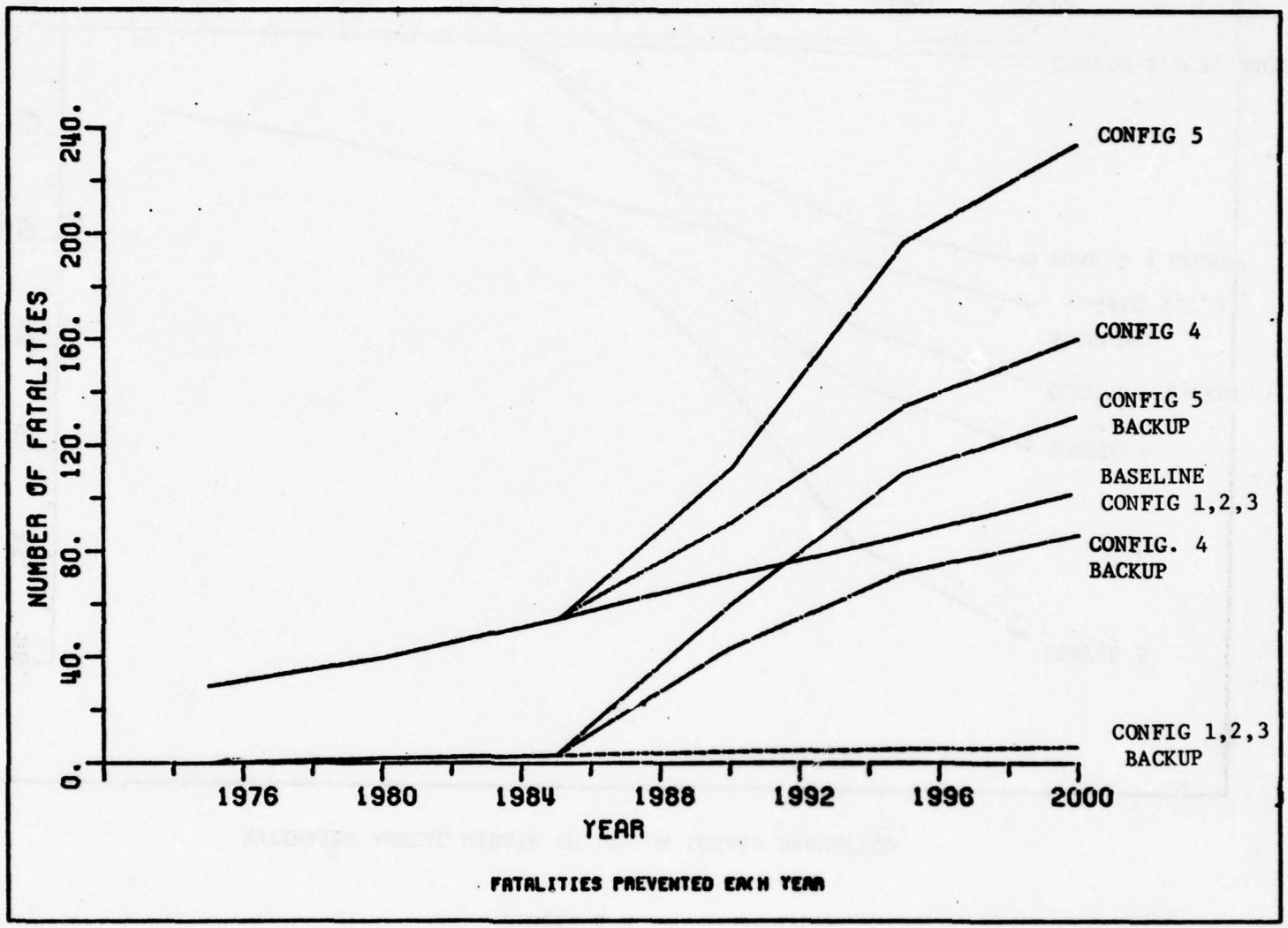
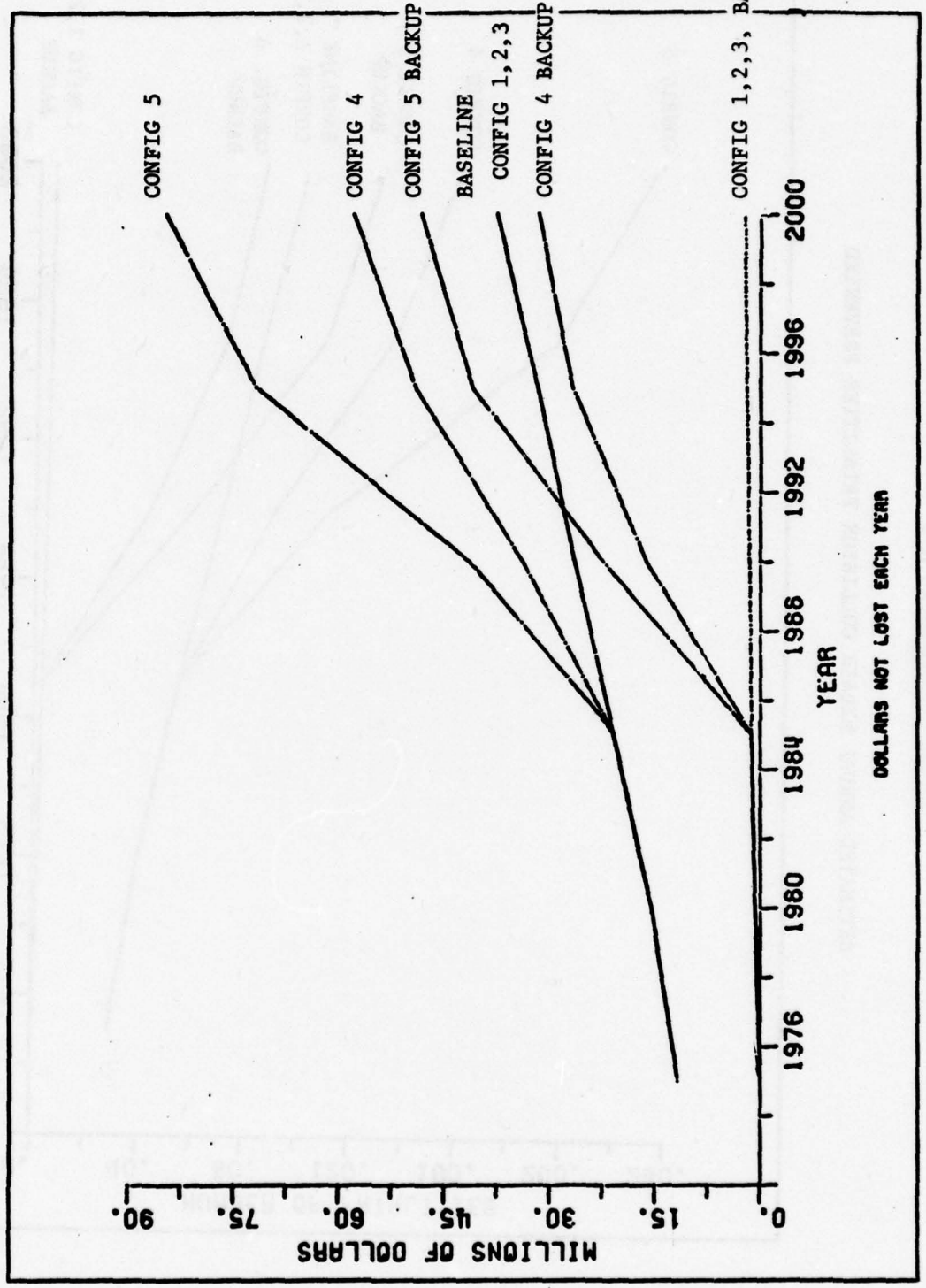


FIGURE A-3

ESTIMATED ANNUAL MIDAIR COLLISION LOSSES PREVENTED



APPENDIX B

ESTIMATED CONCEIVABLY PREVENTABLE CONTROLLED COLLISION WITH THE TERRAIN ACCIDENTS

Listed in this appendix is the computer output for the safety estimation program for fatal and non-fatal accidents for each user class (air carrier, air taxi, and general aviation) for the 1975 - 2000 time period in the controlled collision with the terrain category. Tables B-1 through B-4 give the number of accidents, fatalities, serious injuries, aircraft destroyed, and aircraft damaged that are conceivably presentable by the seven configurations. Tables B-5 through B-8 give the estimated value of the conceivably preventable losses, and Tables B-9 through B-12 restate these results incorporating a 10% annual discounting factor. Figures B-1, B-2, and B-3 give an annual plot of estimated conceivably preventable accidents, fatalities, and monetary losses, respectively, by configuration. In all of the estimates the value of redundant accident solutions provided by elements of Configuration 1-6 is indicated by the backup preventable category, i.e., losses conceivably prevented by a UG3RD System element as well as a Baseline System element.

TABLE B-1

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	95 (0)	5323 (0)	1133 (0)	95 (0)	0 (0)
NON-FATAL	37 (0)	**** (****)	0 (0)	5 (0)	29 (0)
SUBTOTAL	132 (0)	5323 (0)	1133 (0)	100 (0)	29 (0)
AIR TAXI					
FATAL	64 (0)	249 (0)	20 (0)	64 (0)	0 (0)
NON-FATAL	35 (0)	**** (****)	10 (0)	4 (0)	32 (0)
SUBTOTAL	99 (0)	249 (0)	30 (0)	68 (0)	32 (0)
GENERAL AVIATION					
FATAL	160 (0)	296 (0)	23 (0)	160 (0)	0 (0)
NON-FATAL	84 (0)	**** (****)	15 (0)	12 (0)	71 (0)
SUBTOTAL	244 (0)	296 (0)	38 (0)	172 (0)	71 (0)
TOTAL	475 (0)	5868 (0)	1201 (0)	340 (0)	132 (0)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-2

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION 1,2,3 YEARS 1975-2000
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	95 (32)	5323 (1774)	1133 (378)	95 (32)	0 (0)
NON-FATAL	37 (9)	**** (****)	0 (0)	5 (0)	29 (7)
SUBTOTAL	132 (41)	5323 (1774)	1133 (378)	100 (32)	29 (7)
AIR TAXI					
FATAL	64 (20)	249 (73)	20 (6)	64 (20)	0 (0)
NON-FATAL	35 (17)	**** (****)	10 (3)	4 (2)	32 (14)
SUBTOTAL	99 (37)	249 (73)	30 (9)	68 (22)	32 (14)
GENERAL AVIATION					
FATAL	160 (19)	296 (34)	23 (3)	160 (19)	0 (0)
NON-FATAL	84 (9)	**** (****)	15 (0)	12 (0)	71 (8)
SUBTOTAL	244 (28)	296 (34)	38 (3)	172 (19)	71 (8)
TOTAL	475 (106)	5868 (1881)	1201 (390)	340 (73)	132 (29)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-3

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION - 4 YEARS 1975-2000
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	95 (40)	5323 (2255)	1133 (480)	95 (40)	0 (0)
NON-FATAL	37 (9)	**** (****)	0 (0)	5 (0)	29 (7)
SUBTOTAL	132 (49)	5323 (2255)	1133 (480)	100 (40)	29 (7)
AIR TAXI					
FATAL	58 (29)	374 (114)	30 (9)	98 (29)	0 (0)
NON-FATAL	91 (38)	**** (****)	14 (8)	7 (3)	46 (26)
SUBTOTAL	149 (67)	374 (114)	44 (17)	105 (32)	46 (26)
GENERAL AVIATION					
FATAL	378 (91)	700 (167)	56 (12)	378 (91)	0 (0)
NON-FATAL	179 (59)	**** (****)	32 (10)	25 (9)	153 (51)
SUBTOTAL	557 (150)	700 (167)	88 (22)	403 (100)	153 (51)
TOTAL	838 (256)	6397 (2536)	1265 (519)	608 (172)	228 (84)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-4

ESTIMATED NUMBER OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UGRD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED
AIR CARRIER					
FATAL	95 (42)	5323 (2415)	1133 (514)	95 (42)	0 (0)
NON-FATAL	39 (14)	**** (****)	0 (0)	5 (0)	32 (12)
SUBTOTAL	134 (56)	5323 (2415)	1133 (514)	100 (42)	32 (12)
AIR TAXI					
FATAL	146 (52)	558 (198)	46 (17)	146 (52)	0 (0)
NON-FATAL	79 (46)	**** (****)	22 (11)	10 (7)	69 (40)
SUBTOTAL	225 (98)	558 (198)	68 (28)	156 (59)	69 (40)
GENERAL AVIATION					
FATAL	707 (166)	1310 (309)	104 (24)	707 (166)	0 (0)
NON-FATAL	254 (102)	**** (****)	61 (17)	50 (14)	303 (86)
SUBTOTAL	1061 (268)	1310 (309)	165 (41)	757 (180)	303 (86)
TOTAL	1420 (422)	7191 (2922)	1366 (583)	1013 (281)	404 (138)

ENTRIES WITHIN PARENTHESES REFLECT BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-5

ESTIMATED VALUE OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	55 (0)	1597.1 (0.0)	50.9 (0.0)	568.9 (0.0)	0.0 (0.0)	2217 (0)
NON-FATAL	37 (0)	****** (******)	0.0 (0.0)	22.2 (0.0)	5.9 (0.0)	28 (0)
SUBTOTAL	132 (0)	1597.1 (0.0)	50.9 (0.0)	591.2 (0.0)	5.9 (0.0)	2245 (0)
AIR TAXI						
FATAL	64 (0)	74.7 (0.0)	0.9 (0.0)	13.0 (0.0)	0.0 (0.0)	89 (0)
NON-FATAL	35 (0)	****** (******)	0.4 (0.0)	0.9 (0.0)	2.1 (0.0)	3 (0)
SUBTOTAL	99 (0)	74.7 (0.0)	1.3 (0.0)	13.9 (0.0)	2.1 (0.0)	92 (0)
GENERAL AVIATION						
FATAL	160 (0)	89.3 (0.0)	0.9 (0.0)	8.0 (0.0)	0.0 (0.0)	98 (0)
NON-FATAL	84 (0)	****** (******)	0.5 (0.0)	0.6 (0.0)	1.1 (0.0)	2 (0)
SUBTOTAL	244 (0)	89.3 (0.0)	1.4 (0.0)	8.6 (0.0)	1.1 (0.0)	100 (0)
TOTAL	475 (0)	1761 (0)	54 (0)	614 (0)	9 (0)	2438 (0)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-6

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 1,2,3 YEARS 1975-2030
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	55 (32)	1597.1 (532.4)	50.9 (17.0)	568.9 (189.6)	0.0 (0.0)	2217 (739)
NON-FATAL	77 (9)	****** (******)	0.0 (0.0)	22.2 (5.6)	5.9 (1.5)	28 (7)
SUBTOTAL	132 (41)	1597.1 (532.4)	50.9 (17.0)	591.2 (195.2)	5.9 (1.5)	2245 (746)
AIR TAXI						
FATAL	64 (20)	74.7 (21.8)	0.9 (0.3)	13.0 (3.8)	0.0 (0.0)	89 (26)
NON-FATAL	35 (17)	****** (******)	0.4 (0.2)	0.9 (0.4)	2.1 (0.9)	3 (2)
SUBTOTAL	99 (37)	74.7 (21.8)	1.3 (0.5)	13.9 (4.2)	2.1 (0.9)	92 (27)
GENERAL AVIATION						
FATAL	160 (19)	89.3 (10.3)	0.9 (0.1)	8.0 (0.9)	0.0 (0.0)	98 (11)
NON-FATAL	84 (9)	****** (******)	0.5 (0.1)	0.6 (0.1)	1.1 (0.1)	2 (0)
SUBTOTAL	244 (28)	89.3 (10.3)	1.4 (0.2)	8.6 (1.0)	1.1 (0.1)	100 (12)
TOTAL	475 (106)	1761 (564)	54 (18)	614 (200)	9 (3)	2438 (785)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-7

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 4 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	55 (40)	1597.1 (676.7)	50.9 (21.6)	568.9 (236.9)	0.0 (0.0)	2217 (935)
NON-FATAL	37 (9)	****** (******)	0.0 (0.0)	22.2 (5.6)	5.9 (1.5)	28 (7)
SUBTOTAL	132 (49)	1597.1 (676.7)	50.9 (21.6)	591.2 (242.4)	5.9 (1.5)	2245 (942)
AIR TAXI						
FATAL	58 (23)	112.2 (34.3)	1.4 (0.4)	19.6 (6.0)	0.0 (0.0)	133 (41)
NON-FATAL	91 (36)	****** (******)	0.6 (0.3)	1.3 (0.7)	3.0 (1.7)	5 (3)
SUBTOTAL	149 (59)	112.2 (34.3)	2.0 (0.8)	20.9 (6.7)	3.0 (1.7)	138 (44)
GENERAL AVIATION						
FATAL	378 (91)	210.3 (50.2)	2.1 (0.5)	18.9 (4.5)	0.0 (0.0)	231 (55)
NON-FATAL	179 (59)	****** (******)	1.2 (0.4)	1.3 (0.4)	2.4 (0.8)	5 (2)
SUBTOTAL	557 (150)	210.3 (50.2)	3.3 (0.9)	20.2 (4.9)	2.4 (0.8)	236 (57)
TOTAL	838 (258)	1920 (761)	56 (23)	632 (254)	11 (4)	2619 (1043)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-8

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 0%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	95 (42)	1597.1 (724.8)	50.9 (23.1)	568.9 (252.6)	0.0 (0.0)	2217 (1001)
NON-FATAL	39 (14)	****** (******)	0.0 (0.0)	23.8 (8.8)	6.4 (2.3)	30 (11)
SUBTOTAL	134 (56)	1597.1 (724.8)	50.9 (23.1)	592.8 (261.4)	6.4 (2.3)	2247 (1012)
AIR TAXI						
FATAL	146 (52)	167.3 (59.4)	2.0 (0.7)	29.2 (10.4)	0.0 (0.0)	199 (70)
NON-FATAL	79 (46)	****** (******)	0.9 (0.5)	2.0 (1.2)	4.6 (2.7)	8 (4)
SUBTOTAL	225 (98)	167.3 (59.4)	3.0 (1.3)	31.2 (11.5)	4.6 (2.7)	206 (75)
GENERAL AVIATION						
FATAL	737 (160)	393.0 (92.7)	3.9 (0.9)	35.3 (8.3)	0.0 (0.0)	432 (102)
NON-FATAL	354 (107)	****** (******)	2.3 (0.7)	2.5 (0.7)	4.8 (1.4)	10 (3)
SUBTOTAL	1091 (268)	393.0 (92.7)	6.2 (1.6)	37.8 (9.1)	4.8 (1.4)	442 (105)
TOTAL	1450 (422)	2157 (877)	60 (26)	662 (282)	16 (6)	2895 (1191)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-9

ESTIMATED VALUE OF ACCIDENTS PREVENTED
BASELINE CONFIGURATION YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
28 JAN 76
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	55 (0)	499.7 (0.0)	15.9 (0.0)	194.3 (0.0)	0.0 (0.0)	710 (0)
NON-FATAL	77 (0)	****** (******)	0.0 (0.0)	7.6 (0.0)	2.0 (0.0)	10 (0)
SUBTOTAL	132 (0)	499.7 (0.0)	15.9 (0.0)	201.9 (0.0)	2.0 (0.0)	720 (0)
AIR TAXI						
FATAL	64 (0)	20.9 (0.0)	0.3 (0.0)	3.6 (0.0)	0.0 (0.0)	25 (0)
NON-FATAL	35 (0)	****** (******)	0.1 (0.0)	0.2 (0.0)	0.5 (0.0)	1 (0)
SUBTOTAL	99 (0)	20.9 (0.0)	0.4 (0.0)	3.9 (0.0)	0.5 (0.0)	26 (0)
GENERAL AVIATION						
FATAL	180 (0)	23.5 (0.0)	0.2 (0.0)	2.1 (0.0)	0.0 (0.0)	26 (0)
NON-FATAL	64 (0)	****** (******)	0.1 (0.0)	0.2 (0.0)	0.3 (0.0)	1 (0)
SUBTOTAL	244 (0)	23.5 (0.0)	0.4 (0.0)	2.3 (0.0)	0.3 (0.0)	26 (0)
TOTAL	475 (0)	544 (0)	17 (0)	208 (0)	3 (0)	772 (0)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-10

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 1,2,3 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UGRD COST BENEFIT STUDY
28 JAN 74
15:28:39

USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	95 (30)	499.7 (166.6)	15.9 (5.3)	194.3 (64.8)	0.0 (0.0)	710 (237)
NON-FATAL	37 (9)	****** (******)	0.0 (0.0)	7.6 (1.9)	2.0 (0.5)	10 (2)
SUBTOTAL	132 (41)	499.7 (166.6)	15.9 (5.3)	201.9 (66.7)	2.0 (0.5)	720 (239)
AIR TAXI						
FATAL	64 (20)	20.9 (6.3)	0.3 (0.1)	3.6 (1.1)	0.0 (0.0)	25 (7)
NON-FATAL	35 (17)	****** (******)	0.1 (0.0)	0.2 (0.1)	0.5 (0.2)	1 (0)
SUBTOTAL	99 (37)	20.9 (6.3)	0.4 (0.1)	3.9 (1.2)	0.5 (0.2)	26 (8)
GENERAL AVIATION						
FATAL	160 (19)	23.5 (2.6)	0.2 (0.0)	2.1 (0.2)	0.0 (0.0)	26 (3)
NON-FATAL	84 (9)	****** (******)	0.1 (0.0)	0.2 (0.0)	0.3 (0.0)	1 (0)
SUBTOTAL	244 (28)	23.5 (2.6)	0.4 (0.0)	2.3 (0.2)	0.3 (0.0)	26 (3)
TOTAL	475 (100)	544 (175)	17 (5)	208 (68)	3 (1)	772 (250)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-11

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 4 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
UG3RD COST BENEFIT STUDY
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USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	95 (41)	499.7 (190.9)	15.9 (6.1)	194.3 (72.9)	0.0 (0.0)	710 (270)
NON-FATAL	37 (5)	****** (******)	0.0 (0.0)	7.6 (1.9)	2.0 (0.5)	10 (2)
SUBTOTAL	132 (46)	499.7 (190.9)	15.9 (6.1)	201.9 (74.8)	2.0 (0.5)	720 (272)
AIR TAXI						
FATAL	98 (29)	26.7 (8.2)	0.3 (0.1)	4.7 (1.4)	0.0 (0.0)	32 (10)
NON-FATAL	51 (30)	****** (******)	0.1 (0.1)	0.3 (0.1)	0.7 (0.3)	1 (1)
SUBTOTAL	149 (59)	26.7 (8.2)	0.5 (0.2)	5.0 (1.6)	0.7 (0.3)	33 (10)
GENERAL AVIATION						
FATAL	378 (91)	42.0 (8.6)	0.4 (0.1)	3.8 (0.8)	0.0 (0.0)	46 (9)
NON-FATAL	179 (59)	****** (******)	0.2 (0.1)	0.3 (0.1)	0.5 (0.1)	1 (0)
SUBTOTAL	557 (150)	42.0 (8.6)	0.7 (0.2)	4.0 (0.8)	0.5 (0.1)	47 (10)
TOTAL	828 (258)	568 (208)	17 (6)	211 (77)	3 (1)	799 (292)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES

TABLE B-12

ESTIMATED VALUE OF ACCIDENTS PREVENTED
CONFIGURATION 5 YEARS 1975-2000
VALUE IN MILLIONS OF DOLLARS DISCOUNTED TO 1975 AT 10%
SAFETY ANALYSIS OF CONTROLLED COLLISIONS WITH TERRAIN
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USER CLASS	NUMBER OF ACCIDENTS	FATALITIES	SERIOUS INJURIES	AIRCRAFT DESTROYED	AIRCRAFT DAMAGED	TOTAL
AIR CARRIER						
FATAL	95 (42)	499.7 (199.0)	15.9 (6.3)	194.3 (75.6)	0.0 (0.0)	710 (281)
NON-FATAL	39 (14)	****** (******)	0.0 (0.0)	7.9 (2.5)	2.1 (0.7)	10 (3)
SUBTOTAL	134 (56)	499.7 (199.0)	15.9 (6.3)	202.2 (78.0)	2.1 (0.7)	720 (284)
AIR TAXI						
FATAL	146 (52)	35.1 (12.1)	0.4 (0.1)	6.1 (2.1)	0.0 (0.0)	42 (14)
NON-FATAL	79 (46)	****** (******)	0.2 (0.1)	0.4 (0.2)	0.9 (0.5)	2 (1)
SUBTOTAL	225 (98)	35.1 (12.1)	0.6 (0.2)	6.5 (2.3)	0.9 (0.5)	43 (15)
GENERAL AVIATION						
FATAL	737 (166)	70.0 (15.1)	0.7 (0.2)	6.3 (1.4)	0.0 (0.0)	77 (17)
NON-FATAL	354 (102)	****** (******)	0.4 (0.1)	0.5 (0.1)	0.9 (0.2)	2 (0)
SUBTOTAL	1061 (268)	70.0 (15.1)	1.1 (0.3)	6.7 (1.5)	0.9 (0.2)	79 (17)
TOTAL	1420 (422)	605 (226)	18 (7)	215 (82)	4 (1)	842 (316)

ENTRIES WITHIN PARENTHESES REFLECT VALUES OF BASELINE PREVENTED ACCIDENTS BACKED UP BY CONFIGURATION CAPABILITIES.

FIGURE B-1

ESTIMATED ANNUAL CONTROLLED COLLISION WITH TERRAIN ACCIDENTS PREVENTED

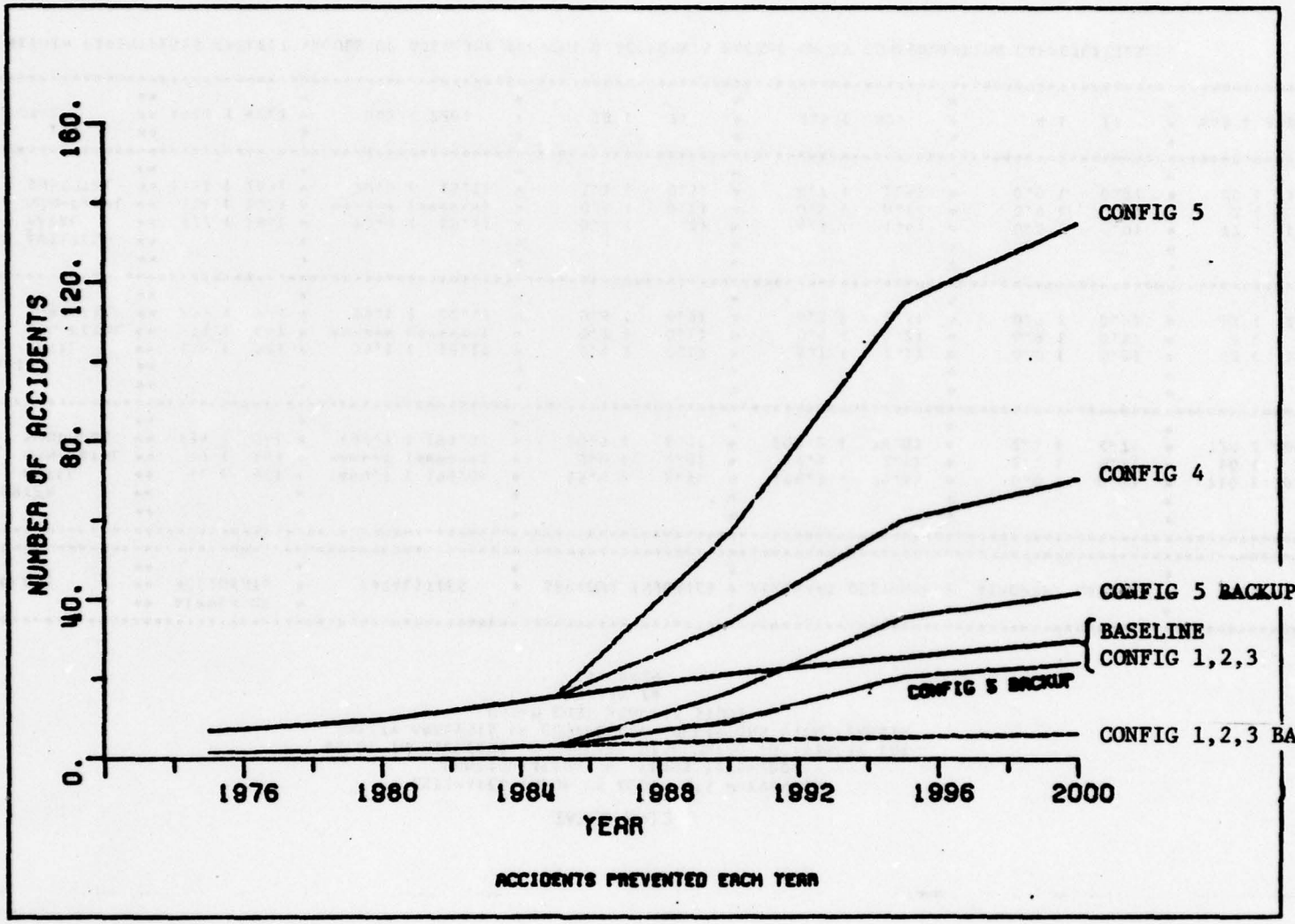


FIGURE B-2

ESTIMATED ANNUAL CONTROLLED COLLISION WITH TERRAIN FATALITIES PREVENTED

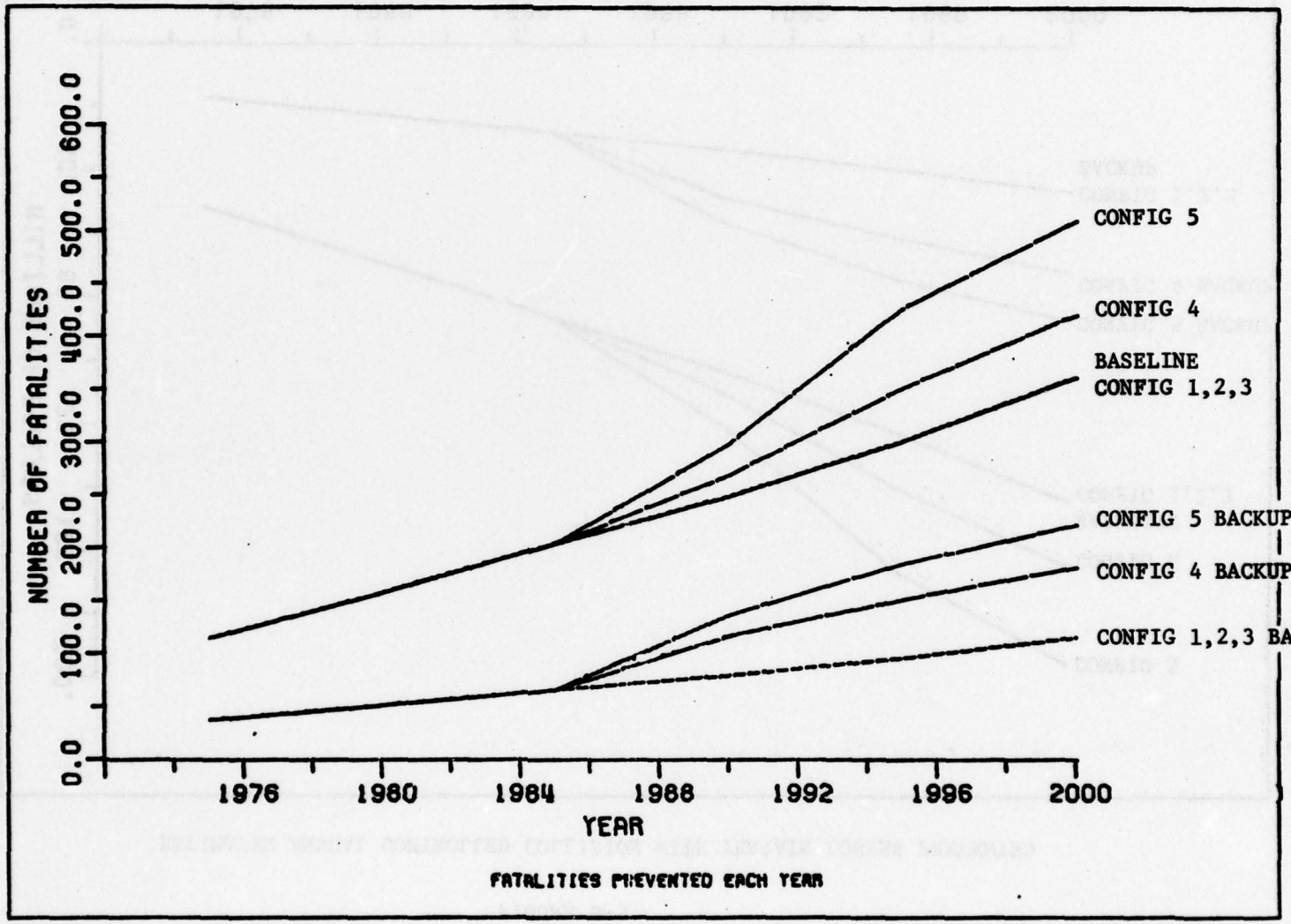
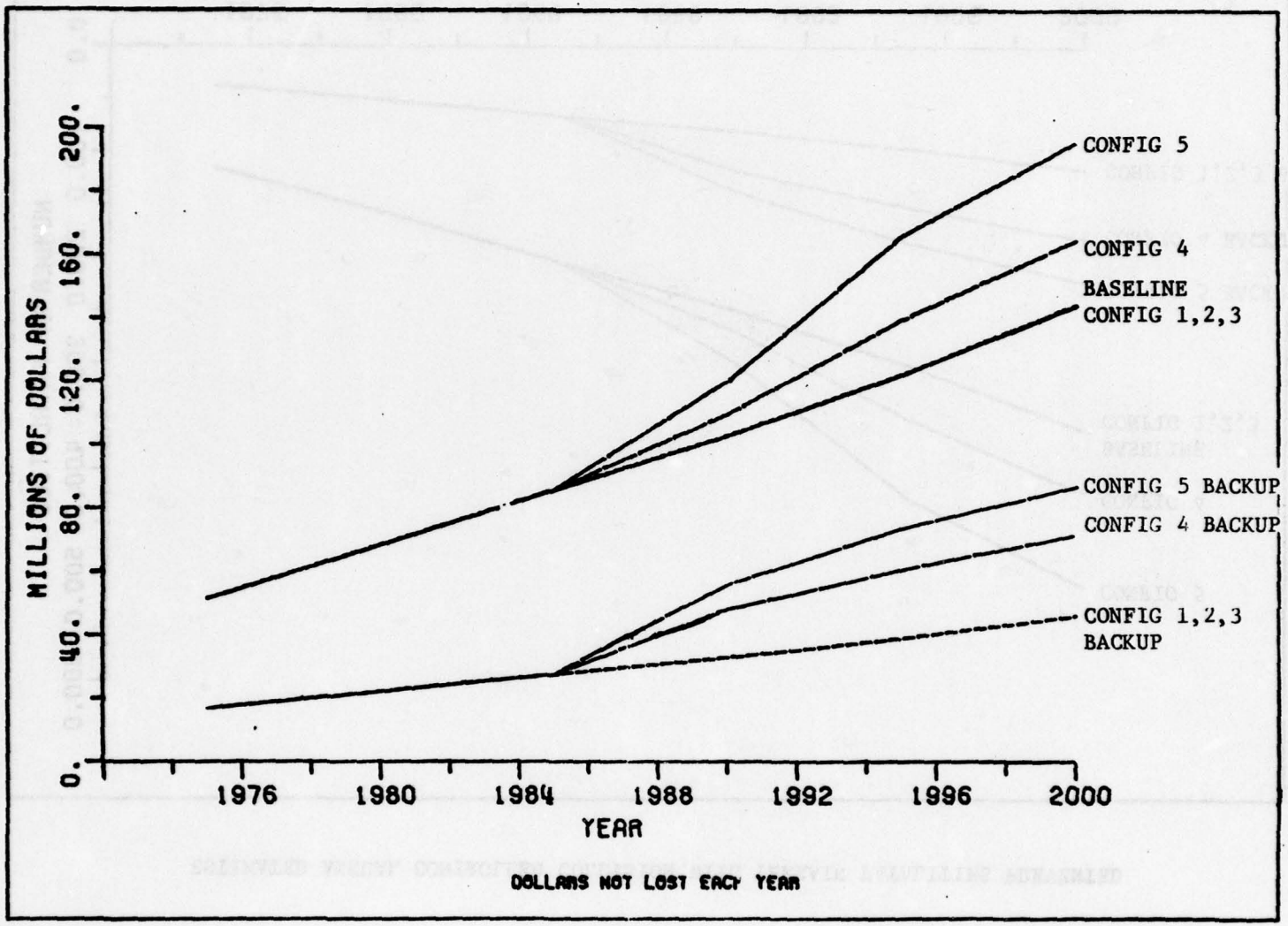


FIGURE B-3

ESTIMATED ANNUAL CONTROLLED COLLISION WITH TERRAIN LOSSES PREVENTED



APPENDIX C

RESULTS WITH A HALF RATE TRAFFIC FORECAST

This appendix contains estimated conceivably preventable losses recalculated with the drastically reduced forecast given in Table C-1. This sensitivity study was undertaken at the request of the study team leaders. The reduced traffic forecast is based on half the annual exponential growth rate exhibited by the nominal forecast used in the previous estimates. This extremely low rate reflects growth that is well below even the lowest expections for aviation growth. The objective was to develop a hypothetical lower bound on the expected impact of the UG3RD.

Estimated conceivably preventable accidents, monetary losses, and discounted monetary losses for the 1975 - 2000 period are given in Tables C-1, C-2, and C-3, respectively, for the half rate traffic growth assumptions. These tables are directly comparable to Tables 3-1, 3-3, and 3-4, respectively.

In terms of modifications of the previous results itemized in Section 4 the reduced forecast make the full UG3RD system slightly less effective in relation to the baseline and reduces the estimated conceivably preventable monetary losses. Retaining the same caveats stated in Section 4 the following results apply:

1. The Full UG3RD (Configuration 5) will conceivably prevent approximately 50% more midair collision accidents and nearly

TABLE C-1

CIVIL AVIATION OPERATIONS

AT CONTROLLED AIRPORTS IN U.S.
(HALF RATE TRAFFIC FORECAST)

HISTORICAL DATA

	OPERATIONS (10^6)			AC ENPLANEMENTS (10^6)
YEAR	AC	AT	GA	
1964-1972	83	15*	299	1132
ANNUAL GROWTH RATE	3.0%	6.4%	6.7%	10.0%

HALF RATE FORECASTS**

	OPERATIONS (10^6)			AC ENPLANEMENTS (10^6)
YEAR	AC	AT	GA	
1975	9.8	2.5	46.2	200.7
1980	10.9	2.8	52.9	236.0
1985	11.5	3.4	66.6	264.5
1990	12.2	4.1	79.4	290.0
1995	12.9	4.5	87.8	319.2
2000	13.6	4.9	95.4	350.6
ANNUAL GROWTH RATE	1.32%	2.73%	2.94%	2.26%

*ESTIMATED FOR 1964 THROUGH 1971 AS 10% OF GA ITINERANT FLIGHTS

**DERIVED BY HALVING THE EXPONENTIAL GROWTH RATE FOR 5 YEAR INTERVALS EXHIBITED BY THE APRIL 9, 1975 FAA FORECAST.

TABLE C-2

ESTIMATED ACCIDENTS PREVENTED WITH
HALF RATE TRAFFIC GROWTH (1975-2000)

	BASELINE	CONFIG 1,2,3	CONFIG 4	CONFIG 5
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 100 DABS/IPC SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 300 DABS/IPC SITES
MIDAIR COLLISIONS				
AIR CARRIER	32	32 (14)	35 (23)	40 (28)
AIR TAXI	26	26 (12)	31 (16)	38 (16)
GENERAL AVIATION	526	526 (60)	677 (142)	812 (174)
SUBTOTAL	584	584 (86)	743 (181)	890 (218)
CONTROLLED COLLISIONS WITH TERRAIN				
AIR CARRIER	107	107 (33)	107 (40)	109 (45)
AIR TAXI	64	64 (24)	91 (37)	134 (60)
GENERAL AVIATION	149	149 (16)	316 (81)	584 (145)
SUBTOTAL	320	320 (73)	514 (158)	827 (250)
TOTAL	904	904 (159)	1257 (339)	1717 (468)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Accidents also prevented by other elements in the configuration

TABLE C-3

ESTIMATED LOSSES PREVENTED WITH HALF RATE TRAFFIC GROWTH (1975-2000)
$M, NON-DISCOUNTED

	BASELINE	CONFIG 1,2,3	CONFIG 4	CONFIG 5
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES	.BASELINE .30 TCP AND ARTS .100 DABS/IPC SITES	.BASELINE .30 TCP AND ARTS MSAW SITES .300 DABS/IPC SITES
MIDAIR COLLISIONS				
AIR CARRIER	306	306 (3)	364 (158)	461 (255)
AIR TAXI	9	9 (1)	12 (5)	16 (5)
GENERAL AVIATION	146	146 (19)	201 (58)	251 (71)
SUBTOTAL	461	461 (22)	577 (221)	728 (331)
CONTROLLED COLLISIONS WITH TERRAIN				
AIR CARRIER	1829	1829 (608)	1829 (758)	1831 (811)
AIR TAXI	59	59 (18)	85 (27)	123 (44)
GENERAL AVIATION	61	61 (7)	134 (31)	244 (57)
SUBTOTAL	1949	1949 (633)	2048 (816)	2198 (912)
TOTAL	2410	2410 (655)	2625 (1037)	2926 (1243)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Losses also prevented by other elements in the configuration

TABLE C-4

ESTIMATED LOSSES PREVENTED WITH HALF RATE TRAFFIC GROWTH (1975-2000)
$M, DISCOUNTED AT 10%

	BASELINE	CONFIG 1,2,3	CONFIG 4	CONFIG 5
	. TODAYS SYSTEM . TCA/ERS . EN ROUTE CONFLICT ALERT . GPWS	. BASELINE . 30 TCP AND ARTS MSAW SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 100 DABS/IPC SITES	. BASELINE . 30 TCP AND ARTS MSAW SITES . 300 DABS/IPC SIT
MIDAIR COLLISIONS				
AIR CARRIER	104	104 (1)	144 (26)	129 (41)
AIR TAXI	3	3 (0)	3 (1)	4 (1)
GENERAL AVIATION	48	48 (5)	56 (12)	63 (14)
SUBTOTAL	155	155 (7)	174 (39)	197 (56)
CONTROLLED COLLISIONS WITH TERRAIN				
AIR CARRIER	625	625 (208)	625 (233)	625 (242)
AIR TAXI	19	19 (6)	23 (7)	29 (10)
GENERAL AVIATION	18	18 (2)	30 (6)	47 (10)
SUBTOTAL	662	662 (216)	678 (246)	701 (262)
TOTAL	817	817 (223)	852 (285)	898 (318)

TCP = Terminal Conflict Prediction
( ) = Baseline Prevented Losses also prevented by other elements in the configuration

two and a half times as many controlled collisions with the terrain accidents as continuing with today's Baseline System.

2. The full UG3RD system will conceivably prevent approximately 25% more fatalities than continuing with the Baseline System.

3. In addition, the full UG3RD system will provide a redundant prevention capability for more than 25% of the accidents and more than 40% of the fatalities.

4. A valuation of the increase in conceivably preventable accidents with the full UG3RD above that estimated for the Baseline System over the 1975 - 2000 time frame is $515M ($80M discounted at 10%). A nominal valuation of the redundant prevention capability provided by the full UG3RD system is $1,245M ($320M discounted at 10%).

Thus the half rate traffic growth assumptions reduce the net estimated accident prevention monetary value of the full UG3RD by about 25% and the redundant prevention value by about 20%.

APPENDIX D

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